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INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

ENLARGED MEETING OF THE PERMANENT COMMISSION
(LISBON, 1949.)

QUESTION I.

a) **Mechanisation of the maintenance and renewal of the permanent way.**

b) **Recent improvements relating to reinforced concrete and prestressed concrete sleepers.**
Results obtained.

c) **Recovery and strengthening of metal bridges that have reached the theoretical limit of safety.**

b) Recent improvements relating to reinforced concrete and prestressed concrete sleepers. Results obtained.

REPORT

(Belgium and Colony, Bulgaria, Denmark, Spain, Finland, France and Colonies, Greece, Hungary, Italy, Luxemburg, Norway, Netherlands and Colonies, Poland, Portugal and Colonies, Rumania, Sweden, Switzerland, Czechoslovakia, Turkey and Jugoslavia),

by M. GONON,

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In his Report on Sleepers to the Lucerne Congress in 1947 (1) Mr. LEDUC described the principal types of concrete sleepers evolved by experience, commenting on their faults, their good qualities, the modifications made in their design, together with a summary of the new types under trial or being designed.

The object of the present report is to bring the evolution of the technique of the concrete sleeper up to date,

(1) Bulletin of the *International Railway Congress Association* for March 1947.

together with the research work carried out in this connection in the last two years. It will include :

— a few statistical details ;
— a descriptive part summing up the information collected on the sleepers, their specifications, the methods of manufacture, use and maintenance ;
— a critical part, devoted to the analysis and comparison of the results obtained ;
— a final section entitled « Future perspective » in which an attempt will be made to distinguish the recent tendencies in their evolution and determine the progress still to be made.

SECTION I.

Statistical information.

Table I shows the variations since 1946 in the length of track equipped with concrete sleepers, and the undertakings begun in 1948 or planned for 1949.

Table II gives, for each category of line, the number of sleepers of the different types laid or taken up during the same period.

These two tables show, that as far as the number of sleepers is concerned, the concrete sleeper has not made much progress. In most cases ordinary reinforced concrete sleepers have been used; prestressed concrete sleepers are still in the experimental stage on most Railways; except in France, French West Africa, and to some extent, in Belgium, they have not yet been ordered on any large scale. It is however prestressed sleepers that have been the subject of the greatest number of investigations and researches during the last two years; for this reason we are devoting considerable space to them in our report.

SECTION II.

Description of sleepers in use or projected.

We will consider in turn :

— the sleepers themselves (ordinary reinforced concrete and prestressed concrete);
— the arrangement of the fastenings;
— the specifications concerning the strength of the sleepers and the materials of which they are made.

1. THE SLEEPERS.

a) *Ordinary reinforced concrete sleepers.*

These can be classified into two groups :

— *monoblock sleepers,* in the form of a straight beam, of appreciably trapezoidal section throughout;
— *combined sleepers,* formed of two blocks connected together by one or more steel stays (or sometimes reinforced concrete).

The monoblock sleepers, derived from the ordinary wood sleeper, are the oldest (Calot, Orion in France). They have not changed very much since 1946. Only the Hungarian Rys. have made sleepers of this type on a very large scale. The present type (Pl. 3) is the result of improvements made to the original model, after more than 25 years experience. The thickness of concrete and the length of the sleeper have been increased; the weight of the reinforcement has been reduced to 13.6 kgr. (30 lbs.) whilst increasing the strength. The middle part is hollowed out to 15 mm. ($^{19}/_{32}''$) to prevent it bearing on the ballast. The main reinforcements are curved inwards towards the base in the part under the rail to increase the resistance to bending under rolling loads.

In this same category we may mention likewise :

— the type 1 sleepers of the *Belgian Light Railways* (Pl. 1);
— the sleepers used by the *Brescia Electric Tramways* (Pl. 2 and fig. 1);
— the 02 sleepers of the *Swiss Federal Railways* (Pl. 4).

With the exception of Hungary, the Administrations consulted are now only making combined sleepers. We will describe the types most widely used :

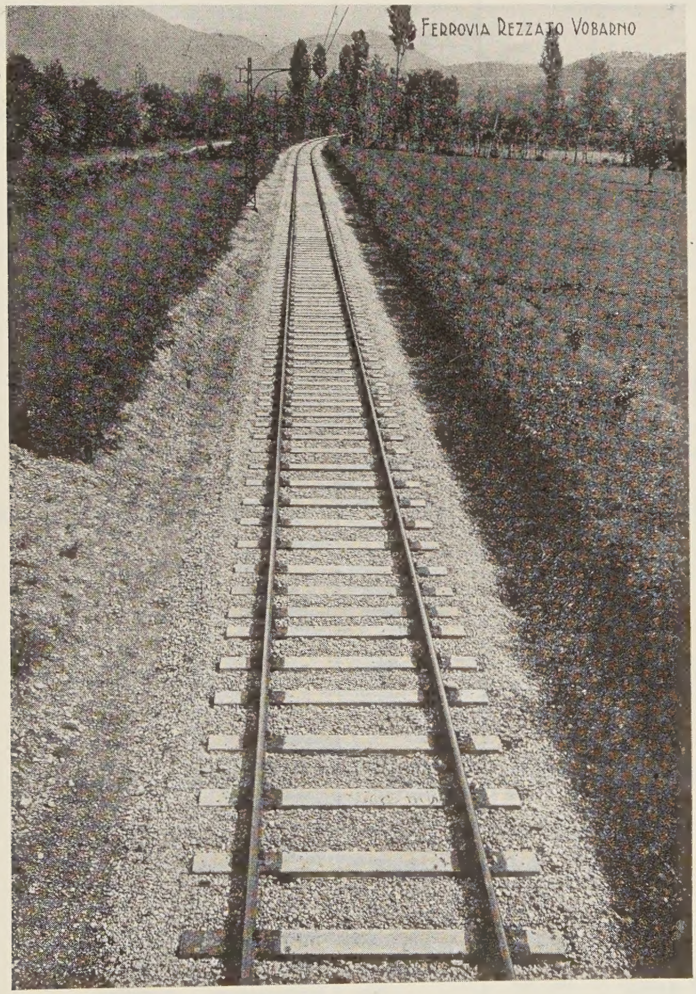


Fig. 1. — Brescia Electric Tramways.
Track laid on monoblock centrifugalized reinforced concrete.

The French « *Vagneux* » *sleeper* which has been extensively ordered in France, Algeria and Morocco (Pl. 7 and figs. 2, 3 and 4) has been in use for more than 20 years. The only recent modifications have been an increase in the length of the tie-bar to 1.75 m. ($5'8^{7}/_{8}''$) in order to increase the strength of the blocks, especially as regards shearing stresses.

To replace the 80/42 I.P.N. channel normally used as a tie-bar — for reasons

TABLE I. —

	Situation in 1946				
	Categories of line				To
	I	II	III	IV	
Algeria	...	...	...	...	151
Tunisia	...	17 km.	...	...	17
Italy	...	...	...	...	310
Swiss Federal Railways	3 km.	...	...	1 km.	4
Morocco	15 km.	...	15 km.	...	30
Hungary	...	...	...	Situation	in 194
Denmark	...	None		...	..
Holland	...	...	...	...	..
Belgium	...	None		...	..
Belgian Light Railways	...	None		...	..
Rumania	...	...	2 km.	...	2 k
Spain	...	...	...	...	..
Poland	No	information	supplied	...	...
French West Africa	No	information	supplied	...	
Brescia Tramways	...	2.5 km.	...	...	2.5 k
S. N. C. F.	122 km.	314 km.	87 km.	67 km.	690 k

Note : 1 km. = 0.6214 mile; 1 m. = 3' 3/8".

DATA.

Carried out between 1946 and 1948					Immediate programme
Categories of line				Total	
I	II	III	IV		
) km.	...	...	+ 40 & — 40	+ 20	60 km. a year to be laid on category I lines.
...	+ 2 km.	...	...	+ 2 km.	Trials of prestressed sleepers.
2 km.	...	...	...	— 2 km.	Various trials to a limited extent.
.5 km.	...	...	...	— 1.5 km.	2 to 3 km. of track on prestressed sleepers.
1 km.	...	...	+ 1 km.	...	16 km. on category IV lines.
4.8	214 km.	161.8 km.	66.4 km.	467 km.	Extensive but no details given.
...	...	...	...	...	Trials on a limited scale.
4 m.	1248 m.	...	345 m.	1617 m.	None.
0 m.	1000 m.	6660 m.	115 km.	122.9 km.	32 km. on category IV lines. 7.6 km. on category III lines,
...	...	1550 m.	526 m.	2076 m.	None.
...	...	None	...	...	None.
0 m.	...	...	...	90 m.	No details.
8 m.	3906 m.	7896 m.	...	12.8 km.	60 km. in 1948, 300 km. in 1949.
...	...	None	...	...	60 km. in 1948 and 1949.
...	...	None	...	...	None.
	A few	trials	...	...	300 km. in 1948-1949 on lines of categories I and II.

TABLE II. — R

	R.C. or P.C.	Categories of lines	Weight of sleepers kgr.	lbs.	Numb of sleep per kr
Algeria	R.C.	I	190	419	1500
	R.C.	III	94	297	1420
Tunisia	R.C.	II	135	298	1500
Italy	P.C.	I	155	341	...
	P.C.	I			...
	R.C.	...	...		...
Switzerland	P.C.	I	...		1556
Morocco	R.C.	IV	185	408	1300 ap
Hungary	R.C.	...	268	590	...
Denmark	P.C.	...	210	462	...
Holland	P.C.	I	210	462	1665
	P.C.	II	...		1333
	R.C.	IV	211	464	1333
Belgium, S. N. C. B.	R.C.	IV	125	265	1400
	P.C.	I	200	440	1600
	P.C.	II	200	440	1500
	P.C.	III	200	440	1500
Belgian Light Railways	R.C.	III	92	202	1200
	R.C.	IV	95	209	1000
	R.C.	III	95	209	1000
Spain	R.C.	I	...		...
	P.C.	I	...		...
Poland	R.C.	I	200	440	1611
	R.C.	II	83	183	1500 app
	R.C.	I	200	440	1600 app
French West Africa	P.C.	II	88	194	1500
S. N. C. F.	R.C.	I & II	185	408	1730
	P.C.	I & II	150	330	1730

AND IMMEDIATE PROGRAMME.

eight of ail lbs.	Insulated track or not	Date of use	Number of sleepers	Remarks
101	no	1947-1948	30 000	Vagneux standard gauge.
79	no	1947	56 800	Vagneux metre gauge.
66	no	1946	3 000	Combined metre gauge.
..	...	1948-1949	90	S. C. A. C.
..	...	...	80	Dow-Mac.
..	...	...	80	Orion.
101	no	1949	3 000 appr.	New design.
	1/2 and 1/2	1948-1949	20 000	Vagneux.
		...	...	
...	...	No information given		
...	...	...	...	Limited trials of Dow-Mac.
101	Insulated	1947	36	Trial Dow-Mac.
101	no	1947	1 664	Dow-Mac.
101	no	1947	420	Combined.
110	no	1946-1948	161 000	Economic.
110	no	1946	450	Franki-Bagon.
110	no	1948	1 500	Franki-Bagon.
110	no	1948	5 000 sleepers 10 000 blocks	Franki-Bagon.
70	no	1947	1 800	Monoblock metre gauge.
2 50 & 70	no	1947	526	Combined metre gauge.
70	no	1947	50	Combined metre gauge.
...	...	1946	100	Combined - trial.
...	...	1946	45	Trial.
94	no	1947-1948	5 884	Combined.
94	no	1947	2 092	Blocks.
94	no	1948-1949	550 000 appr.	New design.
66	no	1948-1949	90 000	Under consideration (metre gauge).
99 to 110	no	1948-1949	200 000	Under consideration (Vagneux).
99 to 110	no	1948-1949	250 000	Under consideration (SCOP).

of economy or because they were easy to obtain, use has been made of :

— a 20 kgr. (44 lbs.) rail (Algeria);
— an old rail cut in two lengthways (Pl. 9);
— old boiler tubes (Tunisia).

The blocks of Vagneux sleepers are very thick and wide; under the rails they are exceptionally strong for ordinary reinforced concrete sleepers. The reinforcement weighs 10.5 kgr. (23 lbs.) per sleeper and is arranged in baskets, of the same shape as the blocks.

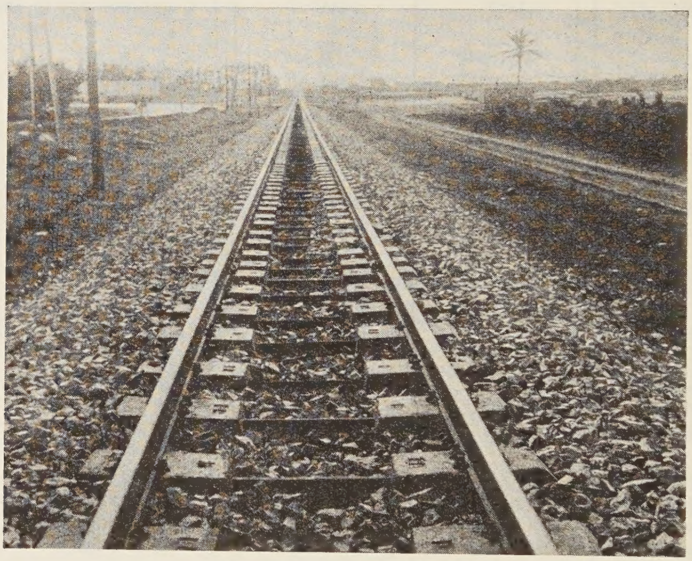


Fig. 2. — Tunisian Railways combined sleepers. Sfax-Tunis line (metre gauge). Fastened by means of coachscrews and spiral fittings.

The *type C sleeper* used on sidings on the *Belgian National Railways* (Pl. 6) was designed to alleviate the shortage of wood sleepers. The main requirements were simplicity and economy. This sleeper, great numbers of which have been produced in the Railway's own shops, consists of two blocks of small size, lightly reinforced, linked up by two boiler tubes which act as tie-bars and also strengthen the blocks.

Other types of combined sleepers have been tried in small quantities :

— type 2 c of the Netherlands Railways (Pl. 11);
— type 2 of the Belgian Light Railways (Pl. 5).

Combined sleepers with reinforced concrete tie-bars. Only the Polish Railways have developed sleepers of this type, of which they have had long experience. On the secondary lines, they are used alternately with complete sleepers for reasons of economy. Considerable quantities of these sleepers have been manufactured at short notice (Pl. 10).

b) *Prestressed concrete sleepers.*

French sleepers.

The prestressed sleepers which have been investigated or designed in France to the orders of the S.N.C.F. all have the same form (Pl. 17 and 18); their chief characteristics are :

— very thick under the rail;

— the concentration of the steel reinforcement in the lower part, as their excentricity favours resistance to positive moments;
— hollowed out in the centre to prevent them bearing on the ballast;
— reduced thickness in the middle to the minimum compatible with the compression of the concrete, so as to obtain the maximum deformability and the minimum weight;
— cylindrical grooves are arranged on each side of the rail to act as a support and stop for the sleeper clips; the latter can be elastic, as will be seen later on.

There are the following variations of this general design :
— *the S.C.O.P. sleeper* (Pl. 17), manufactured by M. FREYSSINET's process, the reinforcement of which consists of 54 parallel bars with the high elastic limit of ø 2.5 mm. ($^{25}/_{250}''$), twisted together in threes, the tension being maintained by adhesion. In one version the reinforcement consists of ø 3 mm. ($^{1}/_{8}''$) bars twisted in pairs, giving an equivalent prestress;
— *the S.T.U.P. type FP23 sleeper* already described in M. LEDUC's Report to the Lucerne Congress;
— *the « Brignoud » sleeper,* manufactured according to the FREYSSINET process (Pl. 18) reinforced by a skein of ø 2.5 mm. « curled » bars with a high limit of elasticity;
— *the « S.N.C.F.-Weinberg » sleeper,* with hard steel reinforcement, about 90 kgr./mm^2 (57.14 tons per sq. inch) of ø 5 to 9 mm. ($^{13}/_{64}''$ to $^{3}/_{8}''$);
— *the Freyssinet-S.T.U.P. sleeper* for metric gauge lines (Pl. 24) which the French West African Railways have had manufactured, which is very similar to the S.C.O.P. sleeper but with reinforcement consisting of ø 3 mm. ($^{1}/_{8}''$) bars grouped in threes.

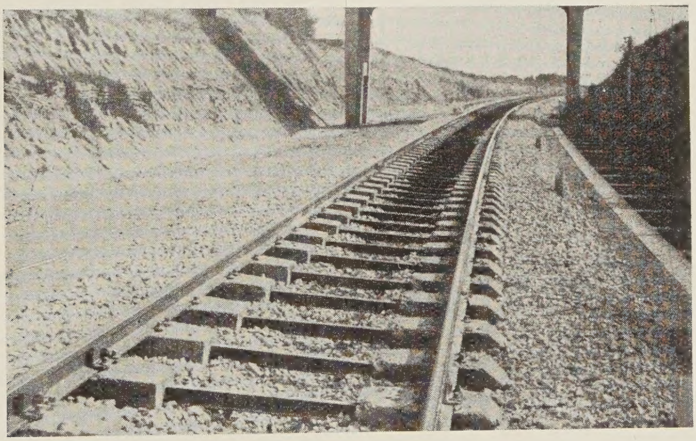


Fig. 3. — Vagneux sleepers in Algeria. Alger-Tunis line.
(Note the new reduced thickness of ballast.)

The reinforcement of these different sleepers is completed by some straps forming hoops, at the ends and in the part under the rail.

The French sleepers differ from those of other countries which have been

given the same rigidity throughout by their reduced thickness in the middle :

— *the Dow-Mac sleeper* (Pl. 14) is being tried out to a limited extent on certain Railways (Holland, Denmark);

— *the S.C.A.C. sleeper of the Italian Railways* (Pl. 26);

— *Swiss sleepers* types I, II and III (Pl. 27, 28, 29).

The Swiss and Italian sleepers have not got beyond the experimental stage.

Finally to complete this review, we will describe the *Belgian Franki-Bagon sleeper* (Pl. 30 and fig. 5) which can be classified as a prestressed sleeper, but is of original design. Put on trial in 1946, it consists of 2 reinforced blocks connected by a tie-bar which is not reinforced, the three pieces being locked together by a manganosilicious steel threaded rod of ø 15 mm. ($^{19}/_{32}''$) given a tension of 55 kgr./mm² (34.92 tons per sq. inch) by tightening up a screw. The compression in the concrete is as much as 70 kgr./cm² (995.632 lbs. per sq. inch). Small plates of resin-bonded plywood inserted between the blocks and cross-pieces make the sleeper semi-articulated. The prestressing of the concrete prevents its cracking; the semi-articulation prevents the centre portion sagging if the supports get out of level.

To reduce the cost of track laid on Franki sleepers, at least in the case of lines of small importance, the Belgian Railways had longitudinal sleepers built by the firm of Franki ($0.50 \times 0.40 \times 0.12$ m. $= 1'7^{11}/_{16}'' \times 1'3\frac{3}{4}'' \times 4\frac{3}{4}''$) which are put between two sleepers. These longitudinal sleepers, which are only ligthly reinforced, merely support the rail, and have no tie-bars.

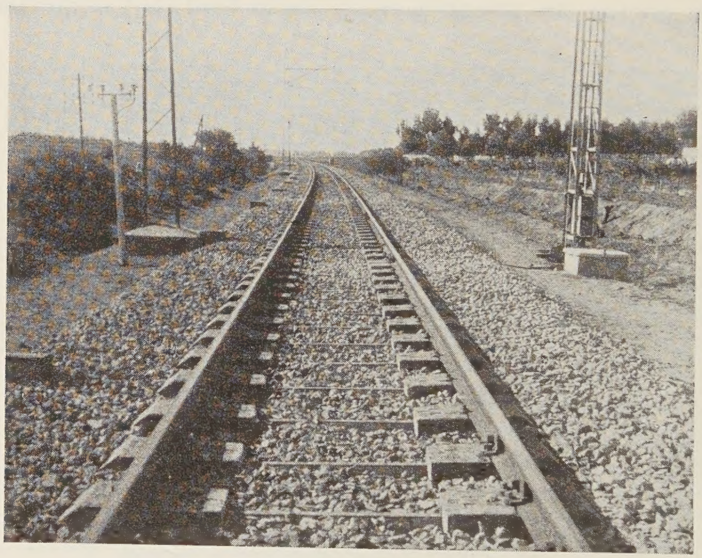


Fig. 4. — Vagneux sleepers on an electrified line of the Morocco Railways. Rabat-Casablanca line. (Fastening by means of coachscrews and insulated Vagneux fittings.)

2. THE FASTENINGS.

Coachscrews.

Coachscrews are still widely used to fasten the rails on concrete sleepers. They are screwed :

— either into hard wood blocks, generally in the form of a frustum of a pyramid (Orion sleeper, Hungarian sleeper, Pl. 3, Franki longitudinal sleeper, Belgian combined sleeper, Pl. 6);

— or into a spiral housing provided in the concrete, the thread being reinforced by a spiral fitting (sleepers for metric gauge lines in Tunisia), the arrangement formerly used on which the sleepers were intended (Pl. 23).

Bolts-coachscrews.

This method, used in France since 1930 on certain Vagneux sleepers, will be made the general practice with all the reinforced or prestressed concrete sleepers manufactured by the S.N.C.F. It is being tested in Algeria. The rail is held either by rolled sleeper clips

Fig. 5. — Belgian National Railways Company line laid on Franki-Bagon sleepers with « Geo-Angleur » bearing plates.

the Vagneux sleepers used in France, Morocco and Algeria (figs. 2 and 3).

Mention may be made here of the insulated fitting made of moulded material used by the Morocco Railways with Vagneux sleepers laid on electrified lines (Pl. 8 and fig. 4).

The coachscrews are generally in direct contact with the rail. Only the Morocco Railways make provision for using sleeper clips to fasten rails of a lighter type on sidings than those for (Vagneux sleeper Pl. 7 and 8), or by elastic sleeper clips (prestressed concrete sleepers, Pl. 19).

Through bolts.

This system which has been the subject of numerous trials in the past, has not been extended; it is now only found on prestressed sleepers on the metric gauge lines of the French West African Railways (Pl. 25) and a few sleepers laid for trial purposes by other Rail-

ways, the bolt being removable or not from above.

The fastening invented by the S.T.U.P. for their type FP 23 sleepers comes under this heading; it consists of a bolt with a trapezoidal head which is wedged in a hollow in the sleeper by means of a fibrocement plate (Pl. 20).

Special fittings.

The Polish Railways use a method of fastening (Pl. 10) consisting of hook shaped fittings embedded in the concrete, which grip the flange of the rail held in place by means of a hardwood wedge.

Bearing plates with seperate fastenings.

Such an arrangement is not often used, probably on account of its weight and cost. The Belgian National Railways has fitted its Franki-Bagon sleepers with « Geo » bearing plates (Pl. 30) of the type used with wood sleepers. Laid on the new concrete at the time of manufacture, the bearing plate is fastened to the sleeper by means of two through bolts. The rail is fixed to the bearing plate by clips and bolts with countersunk heads. The Netherlands and Danish Railways have adopted a similar arrangement for the Dow-Mac sleepers which they are testing (Pl. 15 and 16).

Bearing plates.

Most Railways fit a bearing plate between the rail and the sleeper to avoid the direct contact of steel on concrete. These bearing plates are :

— most often made of impregnated compressed wood (poplar, beech) or bakelised plywood, between 5 and 8 mm. ($^{13}/_{64}''$ to $^{5}/_{16}''$) thick. With the Vagneux French sleepers, the bearing plate is fitted into a hole so that it will not slip;

— sometimes made of rubber. Holland and Italy use rubber plates between the rail and sole plate. In France it is the general practice to use a fluted rubber plate with prestressed sleepers, together with elastic sleeper clips. The same system is being tried in Algeria with Vagneux sleepers;

— finally, certain Railways have given up using bearing plates, for example the French West African Railways. The Hungarian Railways only use bearing plates made of compressed poplar or even reinforced felt under sleepers at joints. The Algerian Railways now lay directly on metal sole plates; the Polish Railways recently decided to give their fittings and wedges a certain elasticity by inserting bearing plates between the rail and between the fittings and the flange.

3. THE SPECIFICATIONS.

a) *Strength of the sleeper.*

From the replies to our questionnaire it would appear that so far no Railway has been able to decide what data shall serve as a basis for calculations concerning the sleeper regarded as a con-

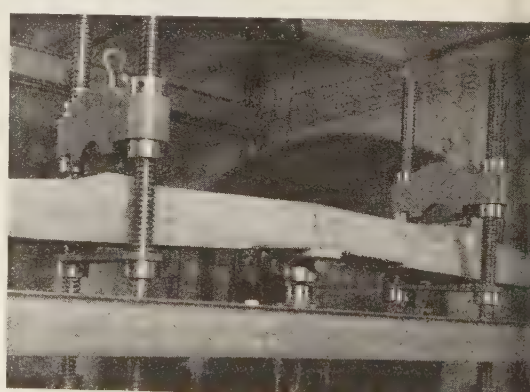


Fig. 6. — Hungarian Railways. Bending test over a whole monoblock sleeper.

tinuous beam on elastic supports. Only the French West African Railways reported the following hypotheses for their metre gauge sleepers :

— load transmitted by the rail : 6.5 t.
— dynamic coefficient: 1.07; coefficient of superelevation : 1.25.
— coefficient of ballast (Schwedler hypothesis) : 14 kgr./cm² per cm. (199.126 lbs. per sq. inch).

Some Administrations have specified the value of the maximum load transmitted by the rail :

Hungary : 8 t. to be increased by 50 % for the dynamic forces (figs. 6 and 7);

Poland : 7 t. to be increased by 50 % for the dynamic forces.

The Italian Railways have specified the maxima moments to be allowed : 200 to 250 000 kgr. (246.051 Engl. tons) × cm. under the rail, 50 000 kgr. (49.21 Engl. tons) × cm. in the middle of the sleeper.

A greater number of Railways have endeavoured to define their reception tests, the main principle of such a test being explained by the sketch given below (Pl. 22), giving the values to be taken into account when l and Q have the following values :

	l mm.	Q t.
French West African Railways (prestressed sleepers for metre gauge lines).	170 (6 11/16")	7
Hungary.	200 (7 7/8")	20
S.N.C.F	200 (7 7/8")	30

The value Q = 30 t. fixed by the S.N.C.F. has been adopted after numerous tests of types of sleepers sanctioned by experience; at first only imposed in the case of prestressed sleepers, this load of 30 t. has since been applied to all concrete sleepers (instead of the 23 t. mentioned at the Lucerne Congress), owing to improvements made in the manufacture of Vagneux sleepers.

It is not considered, however, that the fact that this test has been successfully passed is sufficient to guarantee that a sleeper of a new type will give satisfaction in service : the reception test is merely a simple test of the consistency of the quality of manufacture of sleepers of a type that has passed its trials, either in service, or during the speeded up trials that we shall describe further on.

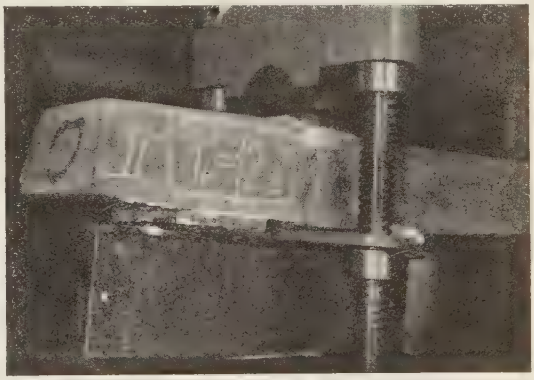


Fig. 7. — Hungarian Railways. Static tests of monoblock sleepers. Bending test under the rail.

The Algerian and Morocco Railways intend to adopt the specifications of the S.N.C.F.

Many Railways leave it to the manufacturers to take the responsibility for the quality and behaviour of the sleepers which they have designed and manufactured, and do not impose any reception tests.

b) Specifications concerning the materials used and the way they are used.

The steel.

In the case of ordinary reinforced concrete the Railways only appear to use the current types of steel on the market, the elastic limit of which is about 25 kgr. (15.87 tons per sq. inch) and the breaking strength 40 kgr./mm^2 (25.40 tons per sq. inch) with an elongation of 25 %. No Railway has reported the use of harder types of steel, nor the use of steel with corrugated or grooved surface to improve the adhesion. The manufacture of the French Orion sleepers (see Lucerne Congress) which are reinforced with twisted grooved steel has been given up by the S.N.C.F., chiefly on account of their high first cost.

In the case of prestressed concrete, the only reinforcements now used are :

— either the wiredrawn « piano string » whose characteristics are summed up below :

	ø 2.5 mm. ($^{25}/_{264}$")	ø 3 mm. ($^1/_8$")
Elastic limit	180	160
Breaking strength . . .	200	180

— or hard steel (S.N.C.F. - Weinberg sleepers) ø 5 to 9 mm. ($^{13}/_{64}$" to $^{23}/_{64}$") elastic limit 90 kgr./mm^2 (57.14 tons per sq. inch).

Unlike the ordinary reinforcements which are not subjected to any special tests, the special reinforcements for prestressed sleepers have to undergo very strict checks as to their elastic limit and elongation in terms of the tension and breaking load. These reinforcements when put under tension are subjected to a working rate very nearly equal to their elastic limit (20 kgr./mm^2 [12.70 tons per sq. inch] below); consequently they are severely tested by the process of manufacture itself, but preliminary tests are intended to prevent the work being disorganised by breakages occurring when they are put under tension.

The concrete.

All the Railways attach great importance to careful control of the composition of the concrete (granulometric composition and C: W ratio).

Ordinary reinforced concrete.

The granulometric composition given is usually continuous, but it appears that there is an evolution in favour of discontinuous granulometric compositions (Hungary — Algeria). The largest elements do not exceed 15 or 20 mm. ($^{19}/_{32}$" or $^{25}/_{32}$") (exceptionally 25 [1 inch] in the case of Vagneux sleepers in France and Algeria). The amount of cement is between 250 and 400 kgr./m^3 (551 and 882 lbs. per m^3). Compression tests would appear to be the chief test of the quality of manufacture, especially in the case of those Railways who do not impose any reception tests for the finished sleepers. Resistance to crushing after 28 days varies from 200 kgr./cm^2 (2 844 lbs. per sq. inch) (Hungary, Algeria, Belgium) to 400 kgr./cm^2 (5 689 lbs. per sq. inch) (Poland, France). Cement with a high initial strength is only used when it is desired to speed up production and reduce the time the moulds are out of use (Hungary, France). It is still hard to get such cement unfortunately, so it is reserved preferably for the manufacture of prestressed concrete.

No Railway has reported speeding up the setting of the concrete by heating. The Algerian Railways immerse their

sleepers for a considerable time as soon as they are taken from the moulds, i.e. about 3 days after they have been made. This precaution, dictated by climatic considerations, has very interesting effects on the strength of the concrete and would seem to increase the adhesion between it and the reinforcement metal.

To sum up, ordinary reinforced concrete sleepers are made of the standard types of concrete. They are all made by mechanical concrete mixers with inclined axis and run into metal moulds. The concrete is usually put into place by vibration :

Hungary : 2.2 H.P. vibrator at 6 000 periods during one minute.

Belgium : vibration at 3 000 periods.

The concrete for the French Vagneux sleepers is simply compressed by a vibro-compactor giving 300 blows per minute. In Algeria, a « Vibrogir » table at 3 000 periods is going to be used instead of the compactor as an experiment.

Fig. 8. — S.C.O.P. plant at Gennevilliers. Shop where the sleepers are manufactured, showing the end of a large bench with the equipment for putting the reinforcement wires under tension.

Prestressed concrete.

The strength of prestressed concrete is required to be greater than that of ordinary reinforced concrete; although the latter is badly adapted for high strength cements, unsuitable for « wire-drawing », prestressing makes it possible to make full use of the strength of the cement under compression.

The French specifications require a strength of 500 kgr./cm² (7 111 lbs. per sq. inch) after 28 days in cubes cut out of a sleeper that has not been reinforced. The French West African Railways stipulate 500 kgr./cm² after 90 days. Finally the Belgian Railways, in the case of their Franki-Bagon sleepers, specify a strength of at least 500 kgr./cm² after 7 days and 700 kgr./cm² (9 956 lbs. per sq. inch) after 28 days.

These characteristics are obtained by very careful choice of the granulometric composition, usually discontinuous, careful selection of the aggregates (finely broken porphyry chips in Belgium) and the gauging with cement of a high initial strength, varying between 450 and 500 kgr./m³ (992 and 1 102 lbs. per cubic metre).

The quantity of water used is as small as possible (6 % of the dry material, in Belgium) and the setting of the concrete is obtained by vibration, usually combined with surface compression (Belgium, French West Africa).

The setting of the concrete is speeded up by running hot water at 80° round the double moulds (France : S.C.O.P.) and sprinkling the surface with water, or by baking at about 95° in a moist atmosphere (S.T.U.P. in France and French West Africa). The loosening of the wires and removal from the mould can take place a few hours after the concrete has been poured, which shortens the time the moulds are out of use; the required strength Q = 30 t. is obtained about 48 hours after removal from the mould.

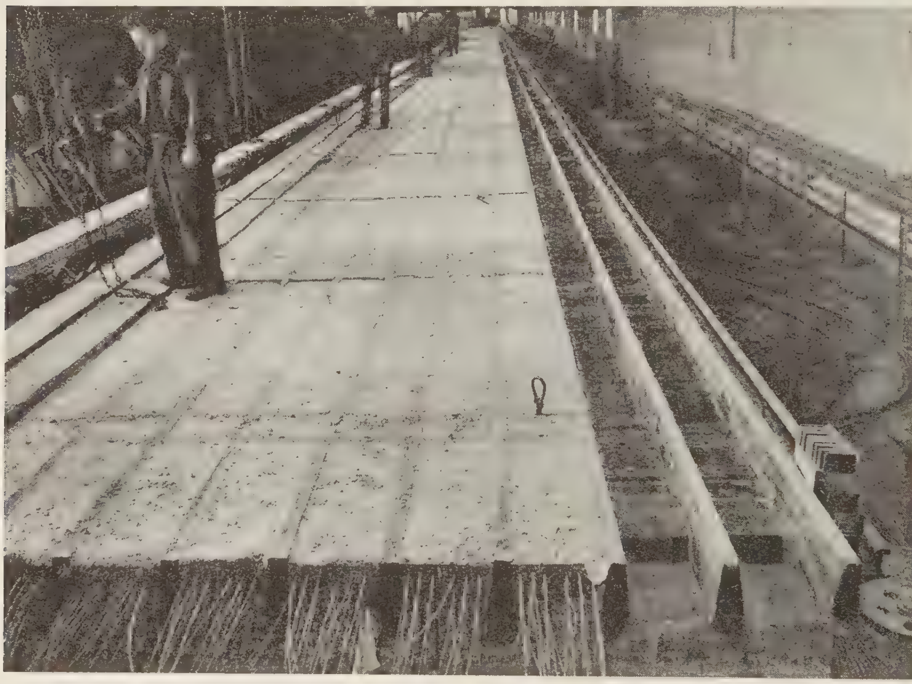


Fig. 9. — S.C.O.P. plant at Gennevilliers. Removing sleepers from the moulds.

4. METHODS OF MANUFACTURE.

The methods of manufacture of *ordinary reinforced concrete sleepers* have not undergone any changes since the Lucerne Congress; on the other hand the manufacture of *prestressed concrete* has been the subject of much research work. We give below a monograph concerning those methods about which we have received detailed information, both those already in use on a large scale, and those which are still being perfected.

French S.C.O.P. sleeper (Freyssinet process) (figs. 8 and 9).

S.C.O.P. sleepers are manufactured at Gennevilliers, near Paris, on a large bench consisting of eleven 110 m. long sections, enabling 495 sleepers to be made at one and the same time. The parallel wires, twisted together in threes to begin with, are fastened to the tensioning apparatus at the two ends of the bench. All the wires, the length of which is minutely regulated, are put under tension at the same time, the tension being regulated by checking the pressure applied to the screws and the elongation (which is about 70 cm. = 2′3½″). The sleepers are separated from each other by metal plates with holes through which the reinforcement wires are threaded.

The concrete which is mixed at one end of the shop is distributed by a traveller to the 11 sections. 2 800 pneumatic vibrators grouped in series which

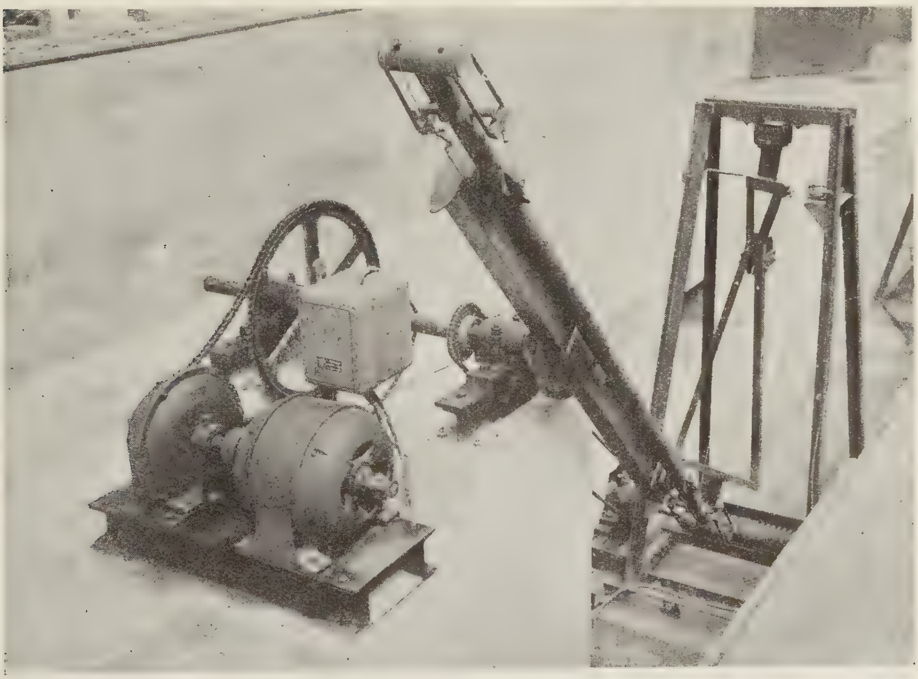


Fig. 10. — « Brignoud » sleeper. Asnieres experimental station. Machine for winding the skeins.

come into action in turn make it possible to regulate the vibration time as the concrete is poured in.

The moulds are double walled; hot water (80°) is run through them to speed up the setting, while atomizers keep the surface of the concrete moist. The tension of the screws is loosened as soon as the concrete exceeds a strength of 300 kgr./cm² (4 267 lbs. per sq. inch), the time it takes to do so depending on the quality of the high initial strength cement used but never exceeding 12 hours. All the sleepers in a section (110 m. = 360′10¾″ long) are removed from the moulds at the same time, by means of a series of blocks and tackle; precautions are taken to see that the bosses supporting the elastic fastenings are not torn away or damaged by the compression of the concrete when the screws are loosened. This stage in the manufacturing process required a great deal of perfecting.

The wires connecting the sleepers together are then cut by electric arc. The sleepers undergo reception tests 48 hours after removal from the moulds. The rate of production is about 500 sleepers in 24 hours.

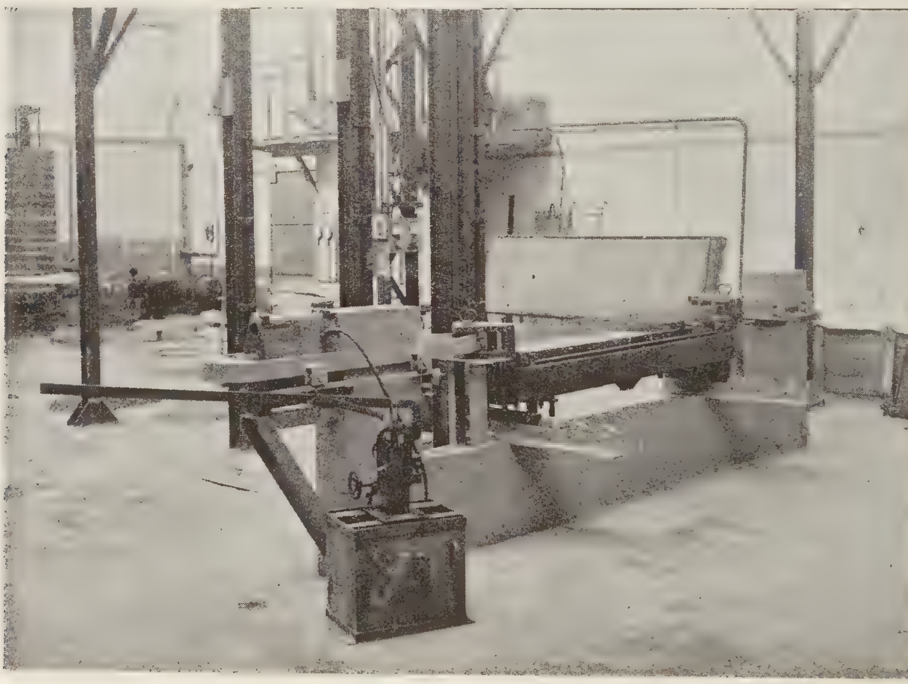


Fig. 11. — « Brignoud » sleeper. Asnieres experimental station.
Tensioning equipment — 30-10-48.

S.T.U.P. sleeper for the metre gauge lines of the French West African Railways.

The Dakar plant is very similar in conception to the S.C.O.P. plant at Gennevilliers. It also consists of benches in parallel lines, but of reduced length

(9 m. only [20′6^3/$_8$″], i.e. 5 sleepers per bench). The benches as well as the tensioning equipment are all separate units; after being run off and vibrated, each bench is taken into a furnace to speed up setting. The sleepers are separated by combs instead of perforated plates, which makes it easier to thread the wires. The output of the factory is about 45 000 sleepers a year. Holes are arranged in the sleeper for the tie-bar by passing a spike through the mould, which is removed before the sleeper part is taken out of the mould. The sleeper parts are taken from the moulds by turning them out onto rolling plates, and removed on parallel chains in such a way that they are in the correct position for assembly as soon as they are strong enough (24 hours).

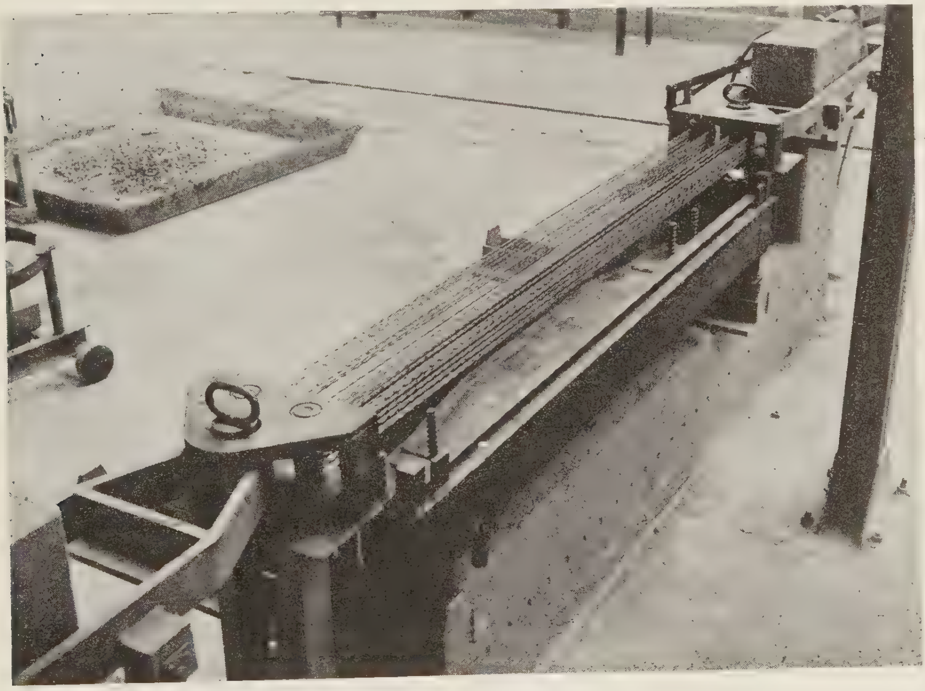


Fig. 12. — « Brignoud » sleeper. Asnieres experimental station. Detail of the equipment for putting the skeins under tension and the mould before the concrete is poured in.

Belgian Franki-Bagon sleeper.

The originality of this manufacturing process lies in the fact that the sleepers are run into fixed moulds and removed from the moulds immediately after vibration. This method involves using concrete with a low water content, which is given exceptionally compactness by compression after vibration.

The reinforcements are made of ordinary steel being prefabricated and assembled entirely by automatic electric welding, without any binding.

The tightening up of the screw intended to put the cross piece under tension is facilitated by means of a set-screw; the cross piece is first of all coated to prevent oxydization.

This manufacturing process is so designed that several hundred sleepers can be produced daily in a rather small shop, the work being organised on rational lines.

Brignoud sleeper (Freyssinet process) (figs. 10, 11 and 12).

The Brignoud sleeper is made in individual moulds. The skeins of metal wire used in the prestressing are made by winding them on two sections of tube which form a spindle, being kept the correct distance apart by means of a longitudinal arm; the winding machine « curls » the wire at the same time to improve adhesion.

The two skeins with their outer spindles are placed in the mould; the vies on the spindles are tightened and setscrews attached to stretch the skeins. The spindles are wedged in the mould so as to maintain the tension after the screws have been undone.

The mould is filled with concrete, under vibration; a lid is fitted to enable the concrete to be compressed. The whole outfit is taken into a furnace; as soon as it has hardened enough to assure adhesion, the mould is placed on a special machine which makes it possible to unwedge the spindles and withdraw them.

At this stage, the ends of the skeins are still visible; the ends of the sleeper still have to be concreted, by means of small moulds in sheeting which extend the central part which has already been made.

S.N.C.F.-Weinberg sleeper.

The manufacture of this sleeper which is on the point of being perfected is characterised by :

— the use of a reinforcement made of hard steel so arranged that it is anchored over a relatively large part of the concrete;

— the use of individual moulds arranged in lines, the prestressing metal running from one end of the line to the other;

– the vibration of the moulds under tension.

This latter point is a definite characteristic of the process perfected by the S.N.C.F. in conjuction with M. WEINBERG for making posts and pylons for the overhead wires.

In the case of sleepers, the moulds are fixed to a longitudinal frame of sheeting which is stretched by different screw-jacks from those used for the prestressing. The concrete is poured out from a moveable tub, and a group of small high frequency vibrators (more than 10 000) fixed to the stretched frame assure the proper bedding of the concrete. Thanks to this method of vibration, it is possible to obtain with very dry concrete of discontinuous granulometric composition rich in fine gravel (granulometric composition specified and perfected by M. VALLETTE, Chief Engineer of the S.N.C.F.) a moulded product of remarkable compactness, strength and appearance. By varying the number of moulds put in series, very flexible output is achieved, so that the process is well adapted to semi-permanent plant.

5. METHODS OF LAYING AND MAINTENANCE.

a) *Methods of laying.*

No Railway has reported any special method used to lay concrete sleepers. The S.N.C.F. has made some modifications in its equipment for laying track assembled in advance (Collet-Loiseau system) because of the great weight of Vagneux sleepers and the space they take compared with wood sleepers.

On the other hand certain renewals using concrete sleepers have been carried out with assembled lengths, by means of a travelling crane running on

the adjacent line. It is also proposed to use the mechanical Drouard track laying machines which were described in M. MUCHERIE's report (*) on the mechanisation of track maintenance and renewal.

The S.N.C.F. have recently made it a practice when renewing the track completely to roll the ballast before laying the new track. This method would seem to be of value in the case of renewals with concrete sleepers, which are of standard thickness, so as to give homogeneous and regular support and prevent the excessive strain to which the sleepers are usually submitted after the track has been renewed owing to irregularities in the newly laid ballast which has been imperfectly tamped.

Finally, the note prepared by the S.N.C.F. on the use of concrete sleepers, recommends the use after renewal of the Scheuchzer tamper owing to the quality of the work it does in the zone near the rails, thus paving the way for the packing work to be done a few months after the track has been renewed.

b) *Maintenance of track laid on reinforced concrete sleepers.*

Kind of ballast.

Apart from the Belgian Railways (fig. 5) who use 40/60 ballast, the Railways are unanimous in recommending the use of ballast under 40 mm. ($1^9/_{16}''$) under concrete sleepers; larger ballast will not give uniform support; this results in straining the sleeper and may even cause breaking, and in any case increased mechanical wear of the concrete owing to the rough surface of large sized ballast. In addition since it is harder to tamp coarse ballast, there is a greater risk of deterioration due to damage to the lower edges. Certain Railways even recommend ramming the sleepers at the time of laying with ballast not exceeding 25 or 30 mm. ($1''$ or $1^3/_{16}''$) (Switzerland, Tunisia).

The Railways using monoblock sleepers take the precaution of making a slight furrow in the centre of the track, to prevent the middle of the sleeper being raised up.

The S.N.C.F. decided (Pl. 21) to profit by the stability given by the great weight of concrete sleepers to reduce the amount of loose ballast. Tests have been carried out over many years on lines equipped with « Orion » sleepers with the ballast only 5 cm. ($2''$) above their lower level. This arrangement, apart from the saving in ballast and maintenance operations, has the advantage of protecting the tie-bars of combined sleepers (Vagneux type) from the damp (observations made in France and above all in Algeria).

Levelling methods.

The Railways use the same methods as with wood sleepers. Tamping should be done very carefully to ensure that the edges of the sleepers are not damaged.

Maintaining the level by measured shovel packing seems to be the best method with concrete sleepers, as the layer of gravel used in packing gives the sleepers a very regular support, which increases their life, as the Tunisian Railways point out.

Methods of alignment.

The alignment of track laid on concrete sleepers does not suffer from any special difficulties other than that of the great weight of such track. One method has been successfully used locally on the French Railways to align the track at the same time as the shovel packing is done. The jacks used to raise the track for the shovel packing are so arranged, that when they are freed, the track will fall back into the

(*) *Bulletin of the International Congress Association* for January 1949.

correct alignment. In other places, heavy track is aligned by means of Simplex jacks set obliquely, resting on the ballast and exerting their thrust against the rail-head.

Track correctly laid on concrete sleepers would appear to maintain its alignment better than track laid on wood sleepers.

SECTION III.

Critical study of the results obtained.

One of the best ways of getting progress in any technique is to criticise the weak points in realisations which have been subjected to the control of experience. This is why we have collected together in a special section the information collected on failures with types of concrete sleepers actually in service, classified as far as possible by their nature. We have also included in this Section the information available about the economic results obtained.

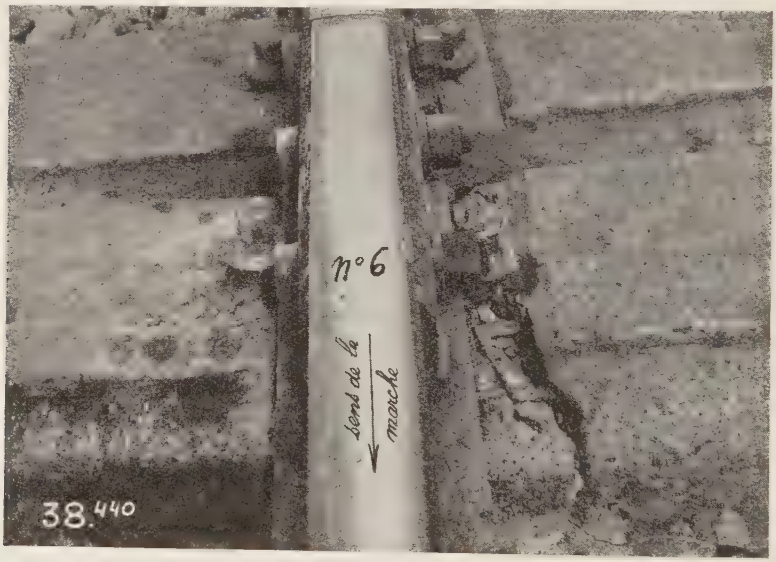


Fig. 13. — Crushing of monoblock sleepers under the rail, near a point.

Tightening up the fastenings.

The same methods and intervals are used as in the case of wood sleepers. Generally, no matter what system of fastening is used, they are tightened up every year. However the Railways who use coachscrews fitted into Thiollier fittings report the difficulty experienced in tightening up the fastenings except in hot weather when the putty is sufficiently soft. This is a serious inconvenience, as the tightening up of the fastenings should normally be done at the beginning of the year, if it is to fit into its proper place in the maintenance cycle.

1. DETERIORATION DUE TO THE ACTION OF ROLLING LOADS.

Crushing under loads (fig. 11).

Damage of this kind is reported by the Morocco Railways in the case of Vagneux sleepers near joints. It is attributed to the hammer blows received from the rails, increased by the presence

of rail-bonds in metal sheeting under electrified lines.

The Hungarian Railways report wear, though not to any great extent (1 to 2 mm. [$^3/_{64}''$ to $^5/_{64}''$]) on the part of the sleeper in direct contact with the rail, if no bearing plate is used. This they remedy by inserting a thin layer of bitumastic concrete.

Finally, the Swiss Railways have found that nearly half the sleepers of prestressed concrete laid in 1946 on a line with heavy fast traffic shows signs of wear in the concrete under the rail, which they attribute to the direct contact.

about 4 years) and the resultant hammer blows from the rails.

The Belgian Railways have discovered a few cracks, of no great seriousness, in line with the rail on some of their « economical » sleepers on sidings. These are due to the deliberately light construction of these sleepers.

Cracks in the centre of the sleeper (fig. 14).

The Polish Railways have discovered cracks of this type in tie-bars made of thin reinforced concrete with their combined types of sleepers. They do not consider the matter of great importance,

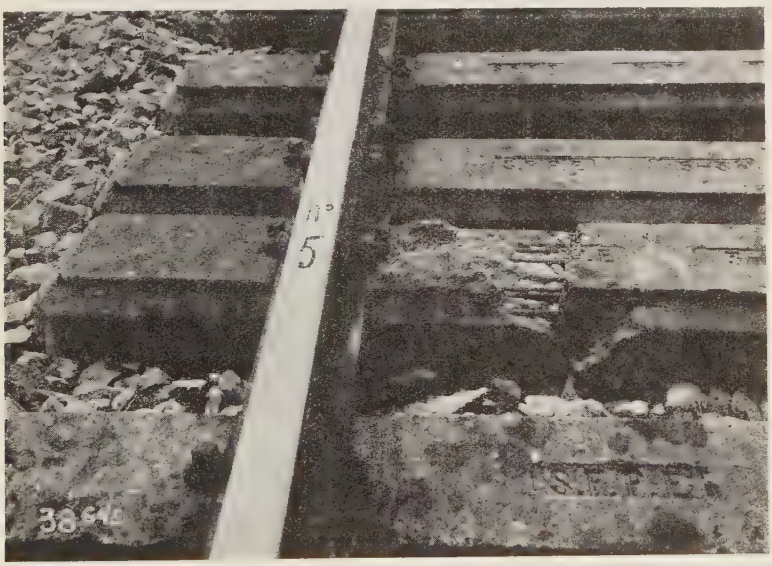


Fig. 14. — Broken monoblock sleeper, the supports of which were out of level.

Cracks under the rail.

These have been reported by the Swiss Railways for prestressed sleepers of types I and III, and by the Morocco Railways with Vagneux sleepers. In the latter case, the damage was due to the almost complete disappearance of the compressed poplar plates which could not be replaced in time (they only last

as such cracks do not interfere with maintaining the gauge of the track which is assured by armatures. These cracks appear to be due to a lack of flexibility in the tie-bars which, moreover, have not sufficient strength to meet the bending stresses which may result from any drop in the relative level of the supports of the blocks.

The Hungarian Railways report a few cracks which started in the lower part of the middle of their monoblock sleepers. These also were due to a relative drop in the supports, which may have been the result of making a furrow in the centre of the track to avoid the much more serious danger of sleepers being raised in the middle.

Longitudinal cracks.

The Swiss Federal Railways have reported cracks of this type on prestressed sleepers of types I and III. This defect calls for attention; should not prestressed concrete sleepers with parallel wires also have transversal reinforcements of some size? There has not been anything similar in the case of the French sleepers in which the prestressed reinforcement is completed by straps or hoops.

Strain near the fastenings.

This defect occurs when ordinary coachscrews are used for the fastenings, screwed into metal fittings; it appears as a superficial splintering of the concrete, on the opposite side to the rail, and even cracks starting from the holes. This is due to the transversal effects on the coachscrews which have to hold the rail laterally by themselves, and above all to the pull and bias of the rail, especially when the wooden bearing plate has been flattened and the fastenings are not tight enough. This defect has never been experienced by the Algerian Railways, even on heavily loaded lines, since they adopted the practice of using metal bearing plates in 1938 (fig. 15), nor by the S.N.C.F. since using bolt-coachscrews and sleeper clips as fastenings (1930). It would appear that the use of wooden bearing plates with Vagneux sleepers fitted with ordinary coachscrews leads to serious damage, which can only be avoided by frequently tightening up the fastenings and replacing the bearing plates as soon

Fig. 15. — Vagneux sleepers - Algeria. Fastening by means of coachscrews and standard bearing plates. Note the excessive packing which has buried the tie-beam (this arrangement has now been abandoned).

as they show any signs of wear. The Morocco, Tunisian Railways and the S.N.C.F. found when using the old type of fastenings with coachscrews and wooden bearing plates the sleepers got out of square and if the plates were not replaced as soon as they showed signs of wear, damage occurred to the sides of the sleeper, owing to hammer blows from the rail on the concrete.

The Morocco Railways who have used insulating fittings with Vagneux sleepers for some dozen years (Pl. 8) to avoid irregularities in the return current, found cracks around these fittings on a certain number of sleepers. They appear to be due to the exterior shape of the fittings which act as keys when there is any pull on the coachscrew and to the absence of any hoop around them. The S.N.C.F. are carrying out trials of a device derived from the Vagneux fitting in bakelite, to solve the problem of insulating concrete sleepers which is of the greatest interest in the case of lines fitted with the automatic block using track circuits.

Fastening by means of ordinary coachscrews screwed into wooden cores also causes drawbacks, especially on curves, where the coachscrews pull outwards and damage the holes in the wood. The Belgian Railways have given up this type of fastening on curves of less than 600 m. (1 968′6″) radius.

It can be stated that whatever method of fastening is used, Thiollier fitting or wood blocks, coachscrews alone, without bearing plates or sleeper clips cannot keep the rails true laterally. This remark does not only apply to concrete sleepers, but has long been noted in the case of wood sleepers.

Fig. 16. — Sleepers damaged after twenty years of maintenance by means of tamping (Algeria).

Finally the S.N.C.F. have found that with prestressed concrete sleepers of the FP 23 type laid for trial purposes in 1945, with trapezoidal headed bolts as fastening, there were slight beginnings of cracks near the holes. These cracks seemed to be due to the wedging effect

of the bolt which vibrations and shocks tended to push progressively out of its seating. This defect was observed on the test machine described further on, after some forty hours.

Damage and wear of the concrete.

The lower edges of concrete sleepers are damaged when tamping is used for maintenance (fig. 16), and the lower face of the sleeper ends by becoming rounded, which is prejudicial to the behaviour of the track and of the fastenings. Moreover the eating away of the concrete by the ballast is far from negligeable in the case of old sleepers, being nearly 1 cm. ($^{13}/_{32}''$) after some twenty years in service. This stresses the value of keeping the reinforcement away from the edges and endeavouring to find a concrete which is resistant to wear, formed of hard aggregates with the minimum of mortar.

On the other hand the eroded surfaces prevent creep and getting out of line owing to lateral forces which are to be feared with a smooth surface.

2. DETERIORATION APART FROM FATIGUE UNDER LOAD.

Rotting of the fastening blocks.

The blocks or wooden cones into which the coachscrews are screwed have a limited life owing to rotting. Whatever precautions are taken in selecting the wood and impregnating it, its life will not exceed 12 to 15 years (Hungarian Railways) or even 10 years (Orion sleepers of the S.N.C.F.). It is often very difficult to replace these blocks, and it involves a great deal of work for the maintenance staff.

Locking the coachscrews.

Owing to the many screwings up and unscrewings made necessary by the short life of the wooden bearing plates used with Vagneux sleepers, the layer of bitumen which protects both the coachscrew and the fitting ends by getting detached and lost, especially in cold weather. Water and foreign matter then penetrate the holes, and end by jamming the coachscrews. In addition coachscrews which are bent cannot be tightened up and frequently break when this is attempted. The Algerian Railways have not experienced any trouble of this kind since they replaced the wood bearing plates by metal ones. They met it previously by renewing the bitumen round the coachscrews under heat about every 8 years. The use of bolt-coachscrews has eliminated this drawback, as when tightening up takes place only the screw is affected, and the coachscrew itself is never touched. After 18 years in service, the bitumastic seals of the bolt-coachscrews used by the S.N.C.F. are still intact.

Oxydisation of the tie-bars.

This is the chief complaint which can be made about combined sleepers with metal tie-bars. More than 20 years experience of Vagneux sleepers shows however that oxydisation is not to be feared if care is taken not to bury the tie-bars under the ballast. Partial encasing of the sections does not appear to have much to recommend it, and it is better to protect the tie-bars against oxydisation by painting with a tar base or other anti-rust paint. The Morocco Railways report that Vagneux sleepers laid more than 10 years ago in shunting lines at Casablanca, beside the sea, and which are under water in high tide periods, are still standing up well in service. On the other hand corrosion due to the use of slag destroys the web of tie-bars of I.P.N. section within twelve years if no special precautions are taken.

It would seem advisable in places where corrosion is to be feared to use tie-bars with less vulnerable sections or heavier ones (old rails for example).

3. ECONOMIC RESULTS.

We sum up below the fragmentary data we received in reply to the questionnaire on the very difficult question of the comparative cost price of track laid on concrete sleepers and track laid on wood sleepers. Three factors have to be taken into consideration in making such a comparison :—

— purchase price;
— life;
— maintenance costs.

Purchase price.

Apart from the « economic » type of combined sleeper used on station sidings by the Belgian Railways, the cost of which is much less than that of a wood sleeper (130 Belgian francs compared with 260) and the combined sleeper used by the Tunisian Railways on their metre gauge lines (800 fr. compared with 900 fr.) concrete sleepers cost more than wood sleepers.

Type of concrete sleeper	Unit price (in currency of the country)	Comparative price of creosoted hardwood sleeper
France : Vagneux or S. C. O. P. (including fastenings and bearing plates)	1 900	1 300
Belgium : Franki-Bagon	350	250
Hungary : Reinforced concrete single unit.	93	74
Poland : Combined in reinforced concrete.	2	1
Algeria : Vagneux (sleeper only).	1 400	1 300
Italy : Single unit as used by Brescia Tramways . .	2	1

The purchase price is not the only consideration affecting a comparison of the cost of laying track on wood or concrete sleepers; the following factors also come into the picture :

— the number of sleepers per km. : it appears that none of the Railways covered by our enquiry have attempted to reduce the number of sleepers when replacing wood sleepers by reinforced concrete, as it is in fact the profile of the rail which determines the sleeper spacing;
— the amount of ballast needed : the section recently adopted by the S.N.C.F. for track laid on concrete sleepers is compared with the section for track on wood sleepers in plate 21. The saving is 0.17 m^3 (6 cubic feet), which at the present cost of ballast means a saving of 135 fr. per metre;
— the cost of transport and laying : the extra cost due to the weight of the concrete sleepers and their fastenings can be taken as 250 fr. per metre.

To sum up, in the case of French lines with 1 700 sleepers per km., the use of concrete sleepers in round figures costs 1 000 000 fr. more per km. than wood sleepers.

Life.

We have only taken into account the data supplied by those Railways with a long experience of concrete sleepers; moreover the provisional character of this information must not be overlooked, owing to the necessity of making premises from the limited experience obtained, or the fact that they are merely estimates.

Here are the figures :

France (S.N.C.F.) : Vagneux : 45 years on average lines and 60 years on secondary lines or sidings (actual experience 20 years).

Prestressed concrete : it is hoped, according to the trials made, that their life is at least equal to that of the Vagneux sleepers, once corrosion of the tie-bars has been eliminated.

Algeria : Vagneux : at least 35 years on lines of categories I and II; 60 years on lines of categories III and IV (16 years experience with the present types).

Hungary : at least 30 years on lines of category I; 40 years on lines of category II; 60 years on lines of categores III and IV (experience of less improved types than the present type: more than 25 years).

Brescia Tramways : probable life at least 30 years (16 years experience).

Morocco : Categories I and II : sleepers not very satisfactory owing to poor fastenings (life about 15 years).

Categories III and IV: 50 to 60 years (similar to metal sleepers).

Apart from the general reservation made above, we must call attention to the following two points :

— the probable life of concrete sleepers on lines with a *great deal of very heavy traffic* is completely unknown, on all the Railways covered by our report; no trials have been carried out on such lines;

— the average estimated life does not take into account any replacements which become necessary during the total life of track laid on concrete sleepers; on certain lines of the S.N.C.F. where there is considerable heavy goods traffic, this amounts to about 1 % per annum in the case of Calot or Vagneux sleepers.

Maintenance costs.

Here again it is difficult to make any comparison; as far as we know no Railway has made any exact comparisons between the cost of maintaining track on wood sleepers and on concrete sleepers, and such a comparison would only be valid for a given intensity of traffic.

From the maintenance point of view, certain types of fastenings form a grave handicap owing to the necessity of replacing the wooden cores into which the coachscrews are screwed (every 10-15 years) or the wooden bearing plates between the rail and concrete (every 4 or 5 years). But as we have seen this drawback can be eliminated.

In spite of this handicap, the Hungarian Railways considered, according to the results obtained over 25 years, that concrete sleepers are more economical than wood sleepers : if they last at least 31 years, the reduced maintenance costs (60 to 70 % of that of track on wood sleepers) make up for the higher purchase price and cost of laying.

The Algerian Railways estimate the maintenance costs per km. of track on Vagneux sleepers with metal bearing plates as 180 000 fr. a year, compared with 280 000 for track on wood sleepers. As creosoted oak sleepers in North Africa will only stand up to the alternate humidity and extreme dryness for 15 years, the use of concrete sleepers, in spite of their high purchase price and cost of laying, gives a saving of about 35 % on renewals alone. Finally this

Railway has decided definitely in favour of concrete sleepers on all categories of line. The savings thus obtained will be further increased by the welding of the rails into 72 m. (236′2¾″) lengths (36 m. [118′1¼″] at the present time) made possible by the stability of track laid on Vagneux sleepers owing to their weight.

The climatic conditions which give such a marked advantage to reinforced concrete sleepers in North Africa do not come into play in France where it is common to find wood sleepers more than 40 years old which are still giving satisfactory service. The reinforced concrete sleepers that have been in use for 20 years all have the handicap of wooden bearing plates which need frequent renewal, and most of them have coachscrew fastenings, the drawbacks of which have been described above; the majority of sleepers which have had to be withdrawn from service were scrapped on account of stuck or bent coachscrews. As a counterpart to these drawbacks it is found that on lines of categories II and III, the level and alignment of the track are rather more stable than with wood sleepers; with concrete it is possible to avoid the costly operations of consolidating the coachscrews and recutting the sleepers; and there are no burnt sleepers. To sum up, the concrete sleeper — of the types so far in use — appears to have the advantage on lines with light traffic where little maintenance is necessary; it bears comparison with wood sleepers on lines with average traffic. But it must be pointed out that on such lines the comparison is between *new* track laid on concrete and *old* track on wood (or track that has been renewed and the sleepers re-used).

The invention of prestressed sleepers and elastic fastenings together with grooved rubber bearing plates, on the other hand, justify high hopes for the future. The field of use of concrete sleepers appears likely to be extended to lines with much heavier traffic than at present. A saving is hoped for on account of the great intervals between periodical maintenance operations in connection with the fastenings and levelling, but experience is still lacking on the subject, and it appears in addition that the concrete sleeper will always find it hard to accommodate itself to the very difficult conditions which the wood sleeper will stand up to on lines with very heavy traffic where the ballast is rapidly polluted, or the joints deformed, and the impact forces on sleepers with a play of several cm. would probably break down even prestressed concrete sleepers.

To conclude this economic review, we think we may say that if the handicap of unduly frequent replacement of the sole plates or fastenings, together with scrapping owing to deformation of the coachscrews can be eliminated, reinforced concrete sleepers result in lower maintenance costs compared with wood sleepers, at least on lines with light or medium traffic, and perhaps on lines with heavy traffic in the case of prestressed sleepers.

Except for those special cases where the life of wood sleepers is very short (North Africa), such savings must reach a very high figure to make good the additional first cost involved. In the case of the S.N.C.F. — where the gap between wood and concrete at the time of laying is only about 50 % — we have seen that track on concrete costs in round figures about 1 000 000 fr. more per km. than track on wood. Allowing 8 % for interest and amortisation charges, if the substitution of concrete for wood is to be a paying proposition, in climatic conditions similar to those obtaining in France, there must be a saving of 80 000 fr. per year and per km. taking the average life of the two kinds of sleeper as approximately equal (about 40 years). This figure is certainly higher than we can expect. It

seems, to sum up, that for the concrete sleeper to be financially interesting, it is necessary :

— that it lasts at least 40 years on the line where it is laid;
— that its purchase price is not more than 50 % higher than that of a wood sleeper.

These conclusions are only valid in any case for *track of the classic type with fishplate joints*. When concrete sleepers are used the additional weight of the superstructure makes it possible to use *very long welded rails*; the suppression of joints makes it possible to maintain the level very easily, even on lines with heavy traffic, which favours the life of concrete sleepers. If these hopes are confirmed by experience, the economic aspect of the question will be altered again, as with welded track, there will be a still greater saving in the renewal of rails in addition to the saving in the maintenance.

To be complete it would also be necessary to compare the concrete sleeper with the metal sleeper; the shortage of steel throughout Europe makes it impossible to manufacture metal sleepers at the present time, so that such a comparison has no interest at the present.

SECTION IV.

Researches and future possibilities.

ADAPTATION OF CONCRETE SLEEPERS TO THE LOADS SUPPORTED.

Up to the present the Railways have usually been interested in concrete sleepers on account of a temporary or permanent shortage of native hardwoods, or for special climatic conditions.

But, whereas the wood sleeper, apart from the methods of impregnation and types of fastenings, can no longer be improved upon, the concrete sleeper is able to profit by recent developments in the use of this material, and it can be asked whether for certain uses, it will not be better than the wood sleeper at a future date, from the technical if not from the economic point of view.

In the last part of our report, we will define the scope of the research work being carried out by the Railways covered by our investigation and the future developments which may be expected therefrom.

The fundamental question if the concrete sleeper is to make progress is that of the loads it can carry. It would appear that many failures have been due to under-estimating the load transmitted by the rail on lines with heavy fast traffic. The measurements carried out by the British Research Service and the L.M.S. in 1942, the results of which were published in the Proceedings of the *Institution of Civil Engineers* (1943-1944) show in fact that owing to the dynamic effects of the vehicles and the heterogeneity of the support of the track the reactions on the chairs can reach very high values, of the order of 25 tons in the case of wheel loads of about 10 tons.

Trials made by the S.N.C.F. with old Vagneux sleepers, which had stood up to very heavy traffic (20 t. per axle) for many years showed that these sleepers would stand up to a load of 30 t. under the rail flange under the conditions laid down in the S.N.C.F. specifications without cracks occurring. On the other hand, other types of sleepers which showed signs of deterioration under the same traffic conditions (cracks and crushing under the rails) could not stand a load of more than 15 t. under static tests without cracking.

These considerations recently led the S.N.C.F. to specify that all sleepers intended for use on the main lines with heavy traffic should be able to stand

a load of 30 t. without cracks appearing, whether made of reinforced concrete or prestressed concrete.

In the case of lines with lighter and slower traffic, less strength is required, especially if great care is taken to maintain the level correctly. It should not be less than 15 t. in any case, even on sidings, or there is a risk of rapid deterioration of the sleepers.

MONOBLOCK OR COMBINED SLEEPER.

From the replies received to our questionnaire, it appears that none of the Railways consulted have made any systematic investigations into the loads transmitted by the rail to the sleepers, into the distribution of the reactions of the ballast against the underside of the sleeper, nor into the stresses set up in the concrete and its reinforcement by the positive or negative moments to which the different parts are submitted; the only precise results available in this connection are those published by the Institution of Civil Engineers, which are extremely interesting.

If a distinction is made between the three different parts of the sleeper :

— the blocks under the rails, extending some 40 cm. (1′3¾″) on each side of the rail;

— the tie-bar between the two blocks;

the English tests (confirmed by the experience of the S.N.C.F.) bring out the importance of the moments in the blocks under the rails; to stand up to them, using the ordinary type of reinforced concrete, the blocks must be made very thick (e.g. the Vagneux sleeper) with an inertia of the order of 20 000 cm^4 (832 402 $inch^4$). The thickness can be considerably reduced if prestressed concrete is used (compare the Vagneux sleeper Pl. 7 and the S.C.O.P. sleeper Pl. 17).

Now let us consider the *tie-bar*. This can be taken as a rigid beam which can:

— either rest on the ballast bedding down in it when stressed : for example the prestressed prismatic English sleepers;

— or merely stand up to, without cracking, the stresses due to changes in the level of the two blocks under the rails, care being taken to see that the sleeper is never resting on the centre portion.

The English have deliberately adopted the first hypothesis : they have designed prestressed concrete sleepers, very heavy ones, which experience has proved to stand up well in service. It would be impossible to meet the same requirements for such high loads as those revealed by the English tests with ordinary reinforced concrete without having a monster sleeper.

Less information is available regarding the stresses corresponding to the second hypothesis. Certain defects of which we have spoken make it appear likely that in the case of ordinary reinforced concrete it is difficult to meet the necessary requirements without the risk of cracks.

Experiences of attenuated stresses made at the Test Laboratories of the Civil Engineering Department of the University of Liege confirm this; it was with the object of making good the destructive effects of changes in the level that M. Bagon with the « Société Franki » designed the semi-articulated sleeper which we described above.

In practice therefore the Railways have generally given up the idea of a rigid tie-bar in the case of ordinary reinforced concrete; though some are still in favour of this design in the case of prestressed concrete. It results in heavy sleepers of simple form, which can easily be mass produced (England) or to hollowed out sections of more complicated design (Switzerland, Italy).

As opposed to the rigid tie-bar, we have :

— *the semi-articulated tie-bar :* the Franki-Bagon sleeper is the only example of this type;

— *the flexible tie-bar :* the ordinary reinforced concrete Vagneux sleeper comes under this heading, which can stand up to 30 t. per rail, and, as we stated above, is capable of improvement as regards the various criticisms levelled against it (fastenings, bearing plates, corrosion of the tie-bar).

The French prestressed sleepers also come into this category, as thanks to the reduction in thickness of the central portion and to prestressing they can stand important geometrical deformations without cracks appearing (1 cm. [13/32″] deflection) as has been proved under dynamic tests. Naturally the reduced thickness in the middle is profited by to prevent the sleeper being carried on the centre portion.

To sum up, from the morphological point of view, 5 designs seem worthy of retention :

Ordinary reinforced concrete	Combined sleeper with flexible (Vagneux) tie-bar.
	Semi-articulated sleeper (Franki-Bagon).
Prestressed concrete	Prismatic rigid sleeper (England).
	Hollow or tubular rigid sleeper (Switzerland, Italy).
	Flexible sleeper (France).

REINFORCED CONCRETE OR PRESTRESSED CONCRETE?

Apart from the considerations of resistance to bending already gone into, prestressed concrete has other advantages :

— reduced weight of the reinforcement (5.8 kgr. [11.72 lbs.] in the case of the S.C.O.P. sleeper compared with 23 kgr. [50.70 lbs.] in the Vagneux sleeper);

— better resistance to cracks under impact; cracks will close up whereas with ordinary reinforced concrete they lead to progressive desintegration.

These advantages are so important that nearly all the Railways, who have used or carried out trials with ordinary reinforced concrete sleepers, have expressed their intention of making prestressed concrete sleepers. The Swiss Federal Railways and the Italian Railways for example, dissatisfied with the poor results obtained with ordinary reinforced concrete sleepers, are concentrating their efforts on prestressed concrete. It is also significant that Railways little affected by the timber shortage, or who have never used reinforced concrete sleepers, are carrying out trials of prestressed concrete sleepers on lines with heavy traffic (Denmark, Holland, Belgium), and that Railways who have reinforced concrete sleepers in service which are considered satisfactory, have also gone in for the manufacture of prestressed concrete sleepers (S.N.C.F.) or express their wish to do so (Poland, Hungary, Tunisia).

We may note in passing that :

— the use of prestressed concrete is necessarily accompanied by researches into improving the concrete itself, as to make full profit of prestressing, it is necessary to submit the concrete to as much compression as possible, so as to prevent the appearance of cracks in the parts which will be stretched by bending under the rails and in the middle portion. To stand up to these compression stresses, which are obtained by stressing the steel as much as possible together with a careful investigation into the different sections and the excentricity, the concrete must have exceptional qualities, su-

perior in every case to those now obtained with ordinary reinforced concrete;

— the application of prestressing to massed produced articles gives rise to very complex manufacturing problems, and involves very extensive investigations. This is only possible for large firms with extensive orders over which the cost can be spread. Apart from the British Railways, the S.N.C.F. is the only Railway which has carried out such researches in view of the estimated production of a million sleepers a year; it has benefited on the other hand by the stimulus of competition between manufacturers.

PROGRESS MADE IN THE CONSTITUENTS OF PRESTRESSED CONCRETE.

a) *The concrete.*

We have noted the arrangements adopted by certain manufacturers to increase the compactness of the concrete and obtain very quickly a high degree of resistance to compression and shearing so that the tensioning apparatus can be released and the moulds freed for further use. Remarkable results have been obtained as concretes have been reported with a very low shrinkage the strength of which exceeds 700 kgr./cm² (9 956 lbs. per sq. inch) after 28 days. This is due to :

— the use of hard broken stones from the quarry, of cubic form, similar to those now used in modern road construction;

— the adoption of discontinuous granulometric composition, with a great deal of gravel, fine particles of sand being eliminated;

— the reduction of the amount of water used (up to 6 % of the dry material);

— the use of high quality cement.

Such concretes are unfortunately very quick setting and hard to mould. They can be made more plastic by increasing the percentage of cement, but beyond 600 kgr./m³ (1 011 lbs. per cubic yard), a film of cement is formed around the reinforcement which decreases the adhesion. It is also possible to speed up the binding of the concrete after vibration, but this method leads to a layer of slop being brought to the top under the compressing cover, and the good appearance of the facing is obtained at the cost of fragility due to the increased hardening of the top layer. Compression should only be applied to perfectly made concrete from which all the air has been removed by effective preliminary vibration. Vibration is extremely important; the methods now used appear capable of improvement. Whereas the vibration frequencies are about 3 000 a minute at the present time and sometimes 6 000 seldom lasting more than one minute, from the experiments carried out by the S.N.C.F. it appears that better results would be obtained with higher frequencies (more than 10 000) for about 4 to 5 minutes, making arrangements (such as the tension of the moulds) to increase the efficiency of the vibration and reduce the power required (S.N.C.F.-Weinberg process).

This process, together with the Vallette granulometric composition, gives remarkably compact concretes with a very high strength, particularly as regards traction and creep.

The use of a high rate of vibration necessarily presupposes the adoption of such a granulometric composition that perfect segregation is obtained, i.e. there must be just sufficient morter to fill in the gaps left by the gravel after making it compact.

Certain recent methods of improving the concrete : aeration, curing, hardening under water, do not appear to have been used so far in connection with sleepers.

Finally the importance of the quality and uniformity of the cement must not be overlooked : these conditions are not generally met by present production, and attention should be called to the Belgian method of manufacturing high strength cement by crushing the slag under water at the time of use, to avoid any irregularities in the supply.

b) *The reinforcement metal.*

The greater the tension, the less metal needed and the less the effects of the contraction and creep of the concrete. On the other hand the creep of the steel which results in a loss of the prestressing in the sleepers after manufacture, increases very rapidly as the limit of elasticity is reached. It is therefore desirable that investigations should be made (none as far as we know have been yet) into the methods of wire drawing hard steels close to their elastic limit, so as to fix the optimum rate of tension to be obtained, as well as into the qualities of steel most apt to creep.

At the present time, the reinforcements used are generally wiredrawn steel of 2.5 to 3 mm. ($^{25}/_{256}''$ to $^{1}/_{8}''$) section with an elastic limit lying between 150 and 180 kgr./mm^2 (95.23 t. or 114.3 t. per sq inch). They are stretched at a lower rate of about 20 kgr./mm^2 (12.70 t. per sq. inch) near the elastic limit. These data are the results of laboratory tests which the makers have kept secret.

From the point of view of cost, it may be justifiable to use steel of lower resistance such as in the S.N.C.F.-Weinberg process where hard rolled steel of 90 kgr./mm^2 (57.14 t. per sq. inch) elastic limit is used; the increase in the weight of the steel to obtain the same constraint (rather more than double) is compensated by the lower price per kgr. (nearly one third). But if 90 kgr. steel has certain advantages, in particular because it is weldable, it has to have a much larger diameter than 2.5 mm. and the adhesion will not be sufficient to maintain the prestressing; it has to be anchored at the ends. This question of adhesion has been gone into very carefully since prestressed concrete made its appearance. The laboratory experiments made in various countries, particularly in France (M. FREYSSINET) and Switzerland (M. BOLOMEY) seem to indicate that the adhesion of smooth wire-drawn steel of a diameter hardly exceeding 3 mm. is sufficient to maintain the prestressing, at least as long as the concrete is not cracked and the steel has not exceeded its elastic limit under an exaggerated stress due to bending.

In spite of this, certain French manufacturers consider it necessary :

— either to increase the adhesion by curling (Brignoud) or by twisting (S.C.O.P.) the wires in order to make the sleepers stand up to the fatigue of many successive cracks without losing their strength or diminishing the prestressing;

— or to substitute for anchoring by adhesion a positive anchorage by making the wires in the form of buckles or skeins (Brignoud).

Only the results obtained on the permanent way will indicate whether such precautions effectively increase the life of the sleepers.

PROGRESS IN MANUFACTURING METHODS.

The only important plant for making prestressed concrete sleepers now in production are based on the large bench principle, in parallel lines (Dow-Mac in England, S.C.O.P. in France).

To assure the production of several hundred thousand sleepers a year, such bench installations have to be on a huge scale. The moulds are immobilised until the concrete has set sufficiently for the tensioning devices to be loosened and

it can be removed from the moulds. In France it has not been found possible to reduce the manufacturing cycle below 24 hours (with heating). The bench method therefore requires a large capital investment. It is badly adapted for extensive organisation and mechanisation or specialised labour, because the work takes place in sudden spurts and the labour and equipment are dispersed.

It would seem that the method might be improved by using shorter benches (those of the S.C.O.P. are 110 m. [350′] long), by working on each line in turn, and keeping the specialised gangs for each operation moving. The installations of the S.T.U.P. in French West Africa are interesting from this point of view and are an improvement on the « inertia » of the system.

Finally, the process recently perfected industrially by the « Société de Wagons de Brignoud » and the S.T.U.P. marks a new stage of evolution. The sleepers are manufactured on the belt system from the preparation of the skein to the final removal from the mould. The normal manufacturing rhythm is about 600 sleepers every 24 hours, and the time taken for the manufacturing cycle of a sleeper is about 3 hours, including the time in the furnace. The equipment is concentrated in a small shop, and more capital is invested in the machinery than in moulds.

We regret that we are unable to give precise details, owing to lack of information, on the methods followed in Switzerland and Italy to manufacture the sleepers shown in the drawings.

As will be seen, the French researches are concerned with the improvement of the method, rather than with the design of the sleeper. We noted at the end of Section III the capital importance of the cost of the concrete sleeper as regards its future, and the choice to be made among the different types of sleepers will depend very largely upon their suitability for mechanised production involving the minimum investment of capital.

PROGRESS IN THE FASTENINGS.

We will not refer again to the drawbacks of wooden parts : cones for the coachscrews, bearing plates. The simple types of fastenings made possible in this way are only suitable for cheap sleepers on lines with very little traffic, and it is essential to make the necessary replacements in good time.

We will only deal with the two most perfected types of fastenings encountered during our enquiries :

— indirect fastening by means of sole plates or bearing plates or chairs with separate fastenings for the rail and the bearing plate;

— direct fastening by means of coachscrews or bolt-coachscrews, screwed into Thiollier fittings, or through bolts.

Many Railways have expressed their preference for *indirect* fastenings, which in fact have definite advantages : the load of the rail is distributed over the concrete over a large area and the rigidity of the bearing plate assists in reducing the unit pressure as well as the bending stresses in the sleeper in line with the rail (especially if the bearing plate is pressed down into the newly made concrete as in the case of Franki sleepers), the rail is fastened on the bearing plate and the bearing plate on the sleeper by large diameter bolts, which can be so tightened up that there is a very close union between the three elements; practically no maintenance is required, apart from an annual tightening up of the screws; finally the sleeper clips holding the rail and the bearing plate together lie on the axis of support, so that when the rail bends under the passing of loads the tightness of the

fastenings is not affected nor are they fatigued.

On the other hand, the bearing plates are heavy and expensive; their rigidity has certain drawbacks when they are resting on concrete, which is less elastic than wood. It is to be feared that vibrations due to irregularities in the surface of the wheels and rails, which cannot be damped out, will give rise to abnormal fatigue of the concrete, deconsolidation of the ballast, and noisy running. It is not likely that rubber bearing plates inserted between the rail and the bearing plate will give any positive results, or are to be recommended, as we shall see further on.

The *direct* fastening is the same as that used up to the present in France with wood sleepers. A first improvement has been to substitute bolt-coachscrews for the ordinary coachscrews. However fastenings improved in this way have one serious drawback : coachscrews screwed into the metal fittings are unable to fulfil the double task of maintaining the rail in the correct vertical and lateral position.

Their behaviour is much improved by the use of a light metal bearing plate (Algeria); a bearing plate of this sort is durable, unlike a wooden bearing plate, and it brings the transverse stress down to the base of the coachscrews which prevents it pulling out on curves. Experience has shown that wear is confined to the point of contact between the rail and the bearing plate, and that the concrete under the plate is not affected, although it is not much higher than the former. The use of metal bearing plates can only be considered in the case of strong sleepers with a wide base as they do not damp out the shocks and vibrations in any way. In adopting *elastic fastenings* (described above) the S.N.C.F. had three objects in view : a saving in the weight of metal equal to that given by prestressing, the protection of the sleeper and the bolt-coachscrew against shocks and vibrations to

Fig. 17. — S.N.C.F. St. Ouen Laboratory. Apparatus for making dynamic tests on sleepers and their fastenings. General view.

increase their life, and economical maintenance.

Grooved rubber bearing plates, which were the subject of lengthy laboratory tests, were fully described in the *Revue Générale des Chemins de fer français* for February 1948. They have undergone extensive trials on the line, and have given the expected results. Their characteristics are fixed by technical specifications which guarantee the standard of manufacture and time they will last.

plates, but did not make it possible to study the behaviour of the sleeper and its fastenings as a whole under vibrations, so they undertook in their St. Ouen Laboratory a series of dynamic tests which we think merit description.

The equipment used (figs. 17, 18, 19) consists of a Vibrogir 12 H.P. apparatus fixed onto a transversal beam resting on a section of track in line with a sleeper. The beam is closely linked up with the rails and the latter are fastened to the sleeper by the fastenings it is

Fig. 18. — S.N.C.F. St. Ouen Laboratory.
Detail of the way the vibrating beam is fastened to the rail.

Elastic sleeper clips have also been the subject of thorough investigations and endurance tests, using a machine with a rhythm of 180 per minute, to reproduce the effects of the rail on the bearing plate with a load of 15 t. followed by a sudden release of pressure which tends to tear out the fastenings. This machine has been run for about 1 000 hours without the slightest signs of fatigue appearing in the fastenings. The S.N.C.F. considered that these tests merely proved the endurance of the sleeper clips and the grooved bearing

desired to test. The frequency of the jars is 3 000 per minute, with stresses of more than 4 t. per plate.

Here are some of the types of fastenings which have been tested, together with the results obtained :—

— a loose fastening on a hardwood sleeper, without bearing plate : the rail penetrated 9 mm. ($^3/_8''$) into the sleeper after 100 hours. This figure gives some idea of the force of the testing apparatus;

— fastening by means of tightly fasten-

ed elastic fastenings (at least 4 t. per rail) on a wood sleeper : the rail had penetrated less than 1 mm. ($^{3}/_{64}''$) into the sleeper after 100 hours without being tightened up again;

— very close fastening of the rail on a prestressed concrete sleeper with pyramidal headed bolts and rigid clips, with a grooved plate between the rail and the sleeper; cracks in the sleeper starting near the bolt holes, accentuated wear after approximately 30 hours, in spite of tightening up the screws considerably several times;

— fastening identical to the above, without rubber bearing plate; stood up well, though having to be tightened up several times, but it was necessary to shovel pack every hour to make good the driving into the ballast of the sleeper; about 1 mm. ($^{3}/_{64}''$) wear of the concrete under the rail, without disintegration;

— fastening with a grooved bearing plate, elastic clip and bolt-coach-screw; no trace of play, no tightening up required, perfect behaviour after 100 hours. Shovel packing necessary every 6 or 8 hours.

The trials not only made it possible to check the behaviour of the elastic type of fastening before adopting it, but give a more precise idea of the conditions to be realised in order to fasten the rail to the sleepers in a durable way. Trials are being carried out to complete the necessary group of measurements, but it is already possible to formulate the following conclusions :

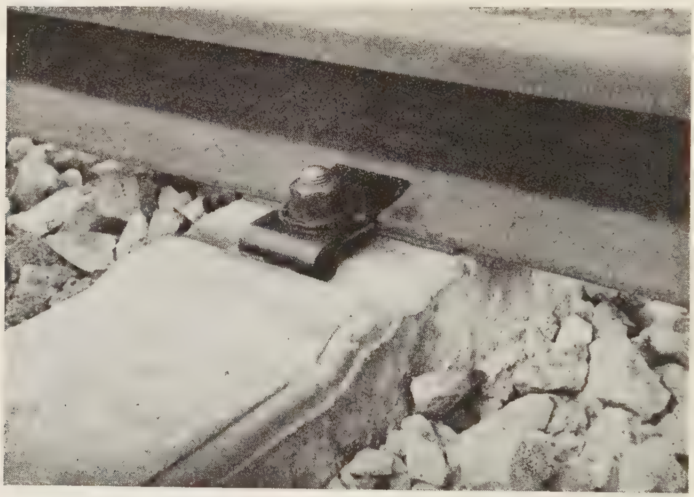


Fig. 19. — S.N.C.F. St. Ouen Laboratory.
Detail of the S.N.C.F. elastic fastening (with grooved bearing plate).

Whatever the type of sleeper, wood or concrete, if the rail and sleeper do not remain in close union during the vibration tests, there is extremely rapid wear of the bearing surface of the sleeper, and this will increase progressively.

If there is perfect union between the rail and the sleeper without an elastic bearing plate, which requires a tight-

ening up force several dozen times the weight of the sleeper, there is practically no deterioration of the sleeper by the rail, but the sleeper digs into the ballast very rapidly, and the ballast vibrates a lot.

If an elastic bearing plate is used, one must also have an equally elastic fastening, tightened up very thoroughly; a rigid fastening combined with an elastic bearing plate deteriorates very rapidly and upsets the stability of the track.

It would appear therefore that in the case of lines with slow traffic and no heavy loads, where it is wished to save the cost of elastic fastenings, it is better to lay the rails directly on the concrete, or with a non-elastic (but durable) bearing plate rather than insert an elastic (rubber) bearing plate or one which will wear very fast (wood). It is essential, in all cases, to maintain the fastenings as tight as possible.

These remarks explain the many cases of failure, but also confirm the value of indirect fastenings kept very tightly screwed up without elastic bearing plate, as well as of the completely elastic type of fastening used by the S.N.C.F. on their heavy, fast lines.

Only experience makes it possible to decide which of these two solutions is the most economical and best adapted to the traffic and the sleepers themselves.

PROGRESS TO BE MADE IN THE MAINTENANCE OF CONCRETE SLEEPERS.

Up to the present, the Railways do not appear to have adopted any different methods for maintaining the level of concrete sleepers than with wood. Concrete sleepers are moreover not yet used sufficiently extensively to justify training staff in special methods. Railways using tamping have not observed any serious deterioration if precautions are taken, such as careful selection of the staff, and of the tamper. It seems however that measured shovel packing or packing with gravel would give better results, assuring greater regularity in the level and uniform distribution of the pressure 0.40 m. (1′$\frac{3}{4}$″) each side of the rail, thereby eliminating the risk of damage.

In view of the present development in the use of concrete sleepers, it would be interesting to investigate thoroughly the effects of the different methods of maintenance on the fatigue of sleepers, by measuring for example with extensometers the tensions in the concrete in order to discover their dispersion and their extreme values. It is especially in the short period immediately after they have been laid that the sleepers are likely to suffer the greatest fatigue; the methods used to obtain the preliminary level and compactness of the ballast have for this reason a decisive effect.

SLEEPERS OR LONGITUDINALS?

Up to the present, the track has been laid on sleepers because this was justified by the normal shape of pieces of wood. Developments in the use of concrete naturally lead to the problem being reconsidered, and make it possible to let the rails rest on the ballast by longitudinal supports.

The manufacture of longitudinal sleepers in reinforced concrete or prestressed concrete does not give rise a priori to any insolvable problems. This method of laying the permanent way has not been much developed to date. We may mention :

— the Valeri longitudinal sleeper (No. 12) of the Italian Railways (Pl. 13),

— the Laval longitudinal sleeper of the S.N.C.F. (Pl. 12).

Laying the track on longitudinal

sleepers makes it possible to reduce the pressure on the bed and fatigue of the rails, and to suppress joints by profiting by the increased weight of the track. But the problem of maintenance for track laid on longitudinal sleepers is hard to solve; it appears difficult in practice to discover the hollows which form under longitudinal sleepers except by the breakages occurring under flexion caused by them. Moreover the gauge of the track and the inclination of the rails are influenced by the heterogeniousness of the transversal support of the longitudinal sleepers, as completely rigid bracing is impossible.

The Italian Railways gave up using Valeri longitudinal sleepers for this reason.

However, without harbouring the illusion that the problem of laying track on longitudinal sleepers can be satisfactorily solved in the near future, it is desirable that tests be made, especially to study the effects of the methods of laying and maintenance, as well as the best forms of longitudinal sleepers and stays. The S.N.C.F. for this reason laid first of all 100 m. (328′) then 400 m. (1312′) of welded track on « Laval » longitudinal sleepers, the stability of which is now under investigation, together with maintenance conditions.

The use of both sleepers and longitudinal sleepers alternately, as practised on lines with little traffic, also deserves attention.

Summaries.

1. — The laying of track on concrete or prestressed concrete sleepers, has not made much progress since the Lucerne Congress, in spite of the timber shortage; this appears to be due to industrial difficulties experienced by the countries covered by our report.

2. — Experience has shown that to avoid failure, it is essential to make the concrete sleepers large enough to carry loads of the order of 30 t. per rail without cracks appearing, in the case of heavy, fast traffic (20 t. axle loads).

3. — The Railways are mainly interested in prestressed sleepers, owing to their greater resistance to impact forces.

However certain types of combined sleepers in ordinary reinforced concrete (Vagneux) appear to be suitable for secondary lines, and might also be used on lines with heavy fast traffic, provided the traffic is not too intense.

4. — Amongst the prestressed concrete sleepers, there is still competition between :

— the prismatic sleepers, simple but heavy (England), the rigid sleepers of hollow form (Switzerland, Italy), the flexible sleepers (France), and the semi-articulated sleepers (Belgium);

— and reinforcements consisting of parallel wires, in which the prestressing is guaranteed solely by adhesion, and curled or skeined reinforcements.

Up to the present no single solution stands out either from the technical nor the economic point of view.

5. — The most satisfactory types of fastenings at the present time are :—

— indirect fastenings, with separate fastening of the rail and bearing plates without elastic bearing plates;

— completely elastic fastenings (grooved rubber bearing plates and elastic clips), with bolt-coachscrews screwed into a Thiollier fitting.

6. — Wooden bearing plates and blocks are unsuitable. Direct fastenings, or the use of metal bearing plates, seem to be suitable for lines without too much traffic.

7. — Trials already made in the laboratory and on the line make it possible

to hope that the prestressed concrete sleepers now manufactured will stand comparison with wood sleepers, even on lines with heavy, fast traffic, especially if fitted with entirely elastic fastenings.

8. — The probable life of concrete sleepers of types that have stood the test of experience is about the same as that of wood sleepers. A considerable reduction in the cost will have to be made if track laid on concrete with ordinary fishplate rails is not to cost more than track laid on wood, both laying and maintenance costs being included, with the exception of certain examples (secondary lines — Mediterranean climate).

9. — If experience confirms that a heavy superstructure is essential if *long welded rails* are to be used without drawback, the economic interest of concrete sleepers may be considerable.

PLATES Nos. 1 to 30.

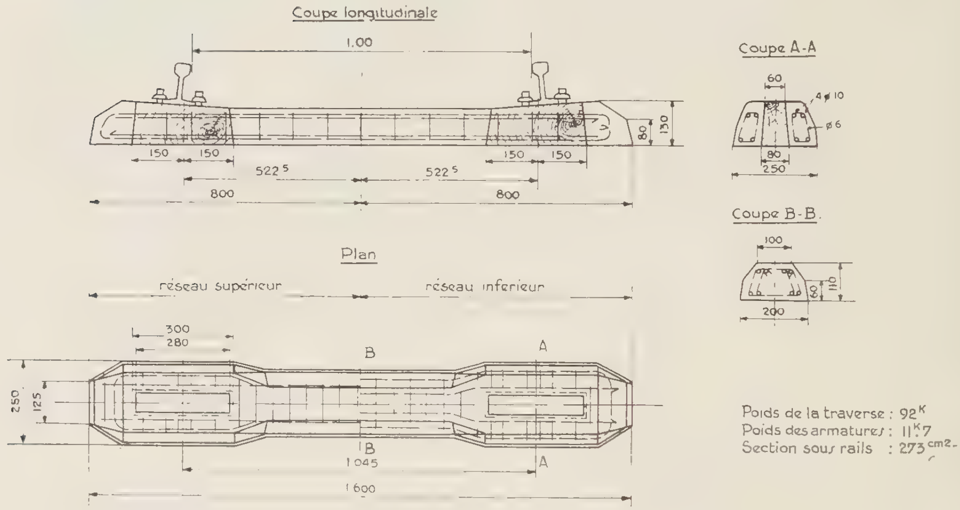


Plate 1. — *Belgian National Light Railways.* Monoblock reinforced concrete sleeper.

Coupe longitudinale = longitudinal section. — Coupe = section.
Réseau supérieur = No. 1 track. — Réseau inférieur = No. 2 track.
Poids de la traverse = weight of sleeper : 92 kgr. (202 lbs.).
Poids des armatures = weight of reinforcement : 11.7 kgr. (26 lbs.).
Section sous rails = section under rails : 273 cm² (42.31 sq. inches).

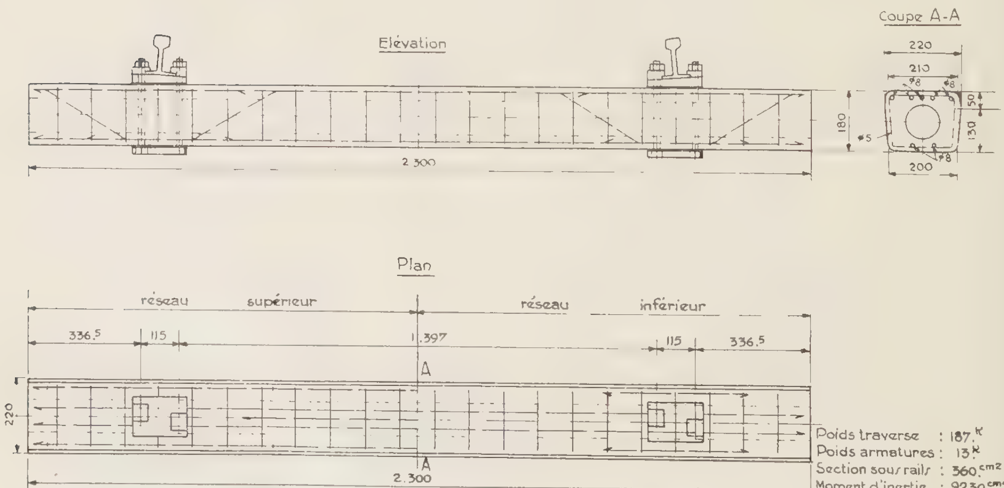


Plate 2. — *Brescia Electric Tramways.* Monoblock centrifugalized reinforced concrete sleeper.

Poids de la traverse = weight of sleeper : 187 kgr. (412 lbs.).
Poids des armatures = weight of reinforcement : 13 kgr. (28 lbs.).
Section sous rails = section under rails : 360 cm² (55.8 sq. inches).
Moment d'inertie = moment of inertia : 9 230 cm⁴ (342 542 inch⁴).

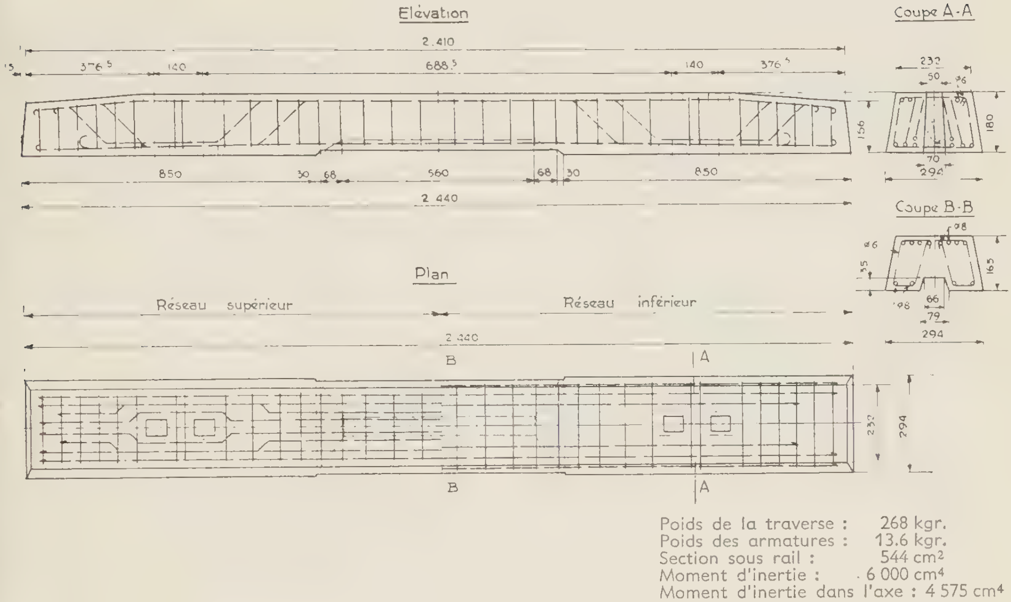


Plate 3. — *Hungarian Railways.* Monoblock reinforced concrete sleeper.

Poids de la traverse = weight of sleeper : 268 kgr. (590 lbs.).
Poids des armatures = weight of reinforcement : 13.6 kgr. (30 lbs.).
Section sous rails = section under rails : 544 cm² (84.32 sq. inches).
Moment d'inertie = moment of inertia : 6 000 cm⁴ (249 687 inch⁴).
Moment d'inertie dans l'axe = moment of inertia in the axis : 4 575 cm⁴ (190 419 inch⁴).

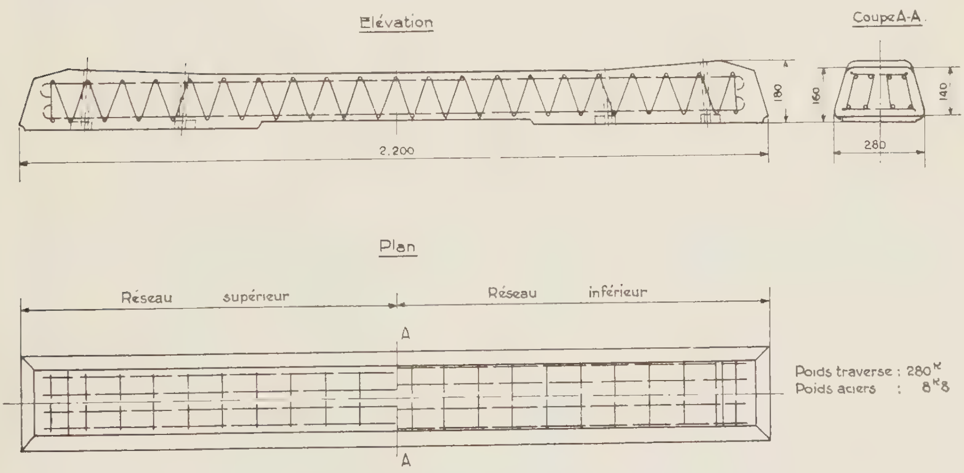


Plate 4. — *Swiss Federal Railways.* Monoblock reinforced concrete sleeper O(2).
Put into service : 1941/1943.

Poids traverse = weight of sleeper : 280 kgr. (617 lbs.).
Poids aciers = weight of reinforcement : 8.8 kgr. (19.4 lbs.).

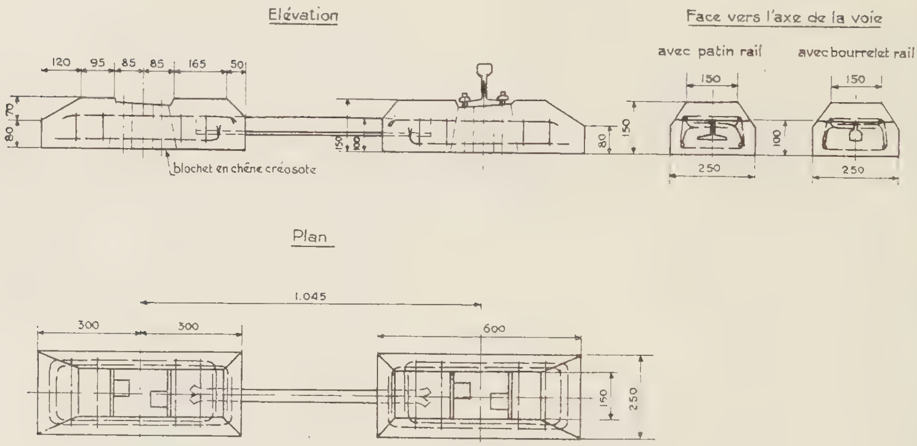


Plate 5. — *Belgian National Light Railways.* Combined reinforced concrete sleeper.

Blochet en chêne créosoté = Creosoted oak block. — Face vers l'axe de la voie = facing the centre of the track. — Avec patin rail = with flat bottom rail. — Avec bourrelet rail = with bull-headed rail.

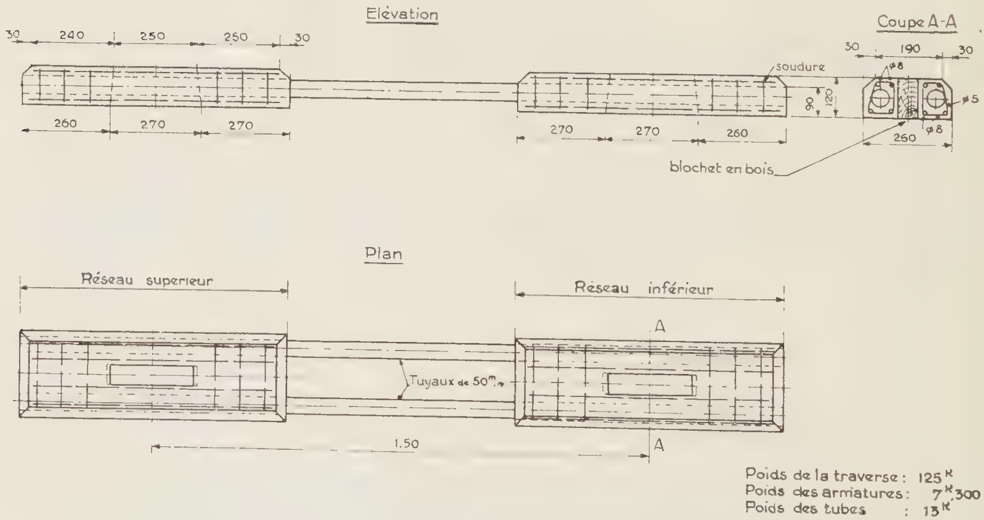


Plate 6. — *Belgian National Light Railways.*

Combined sleeper in reinforced concrete (economic type).

Soudure = weld. — Blochet en bois = wooden block. — Réseau supérieur = No. 1 track. Réseau inférieur = No. 2 track. — Tuyaux de 50 mm. = 50 mm. pipe.

Poids de la traverse = weight of the sleeper : 125 kgr. (275 lbs.).
Poids des armatures = weight of the reinforcement : 7.3 kgr. (18.3 lbs.).
Poids des tubes = weight of the tubes : 13 kgr. (28.66 lbs.).

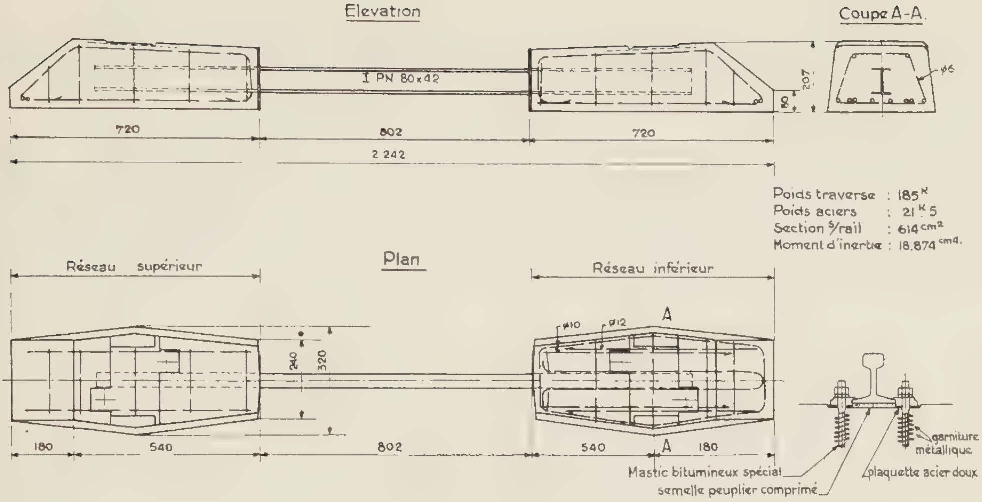


Plate 7. — *French National Railways.*

Combined sleeper in reinforced concrete, Vagneux pattern.

Réseau supérieur = No. 1 track. — Réseau inférieur = No. 2 track. — Mastic bitumineux spécial = special bitumastic compound. — Semelle peuplier comprimé = pressed poplar bearing plate. — garniture métallique = metal fitting. — Plaquette acier doux = mild steel plate.

Poids traverse = weight of sleeper : 185 kgr. (408 lbs.).
Poids aciers = weight of reinforcement : 21.5 kgr. (47.4 lbs.).
Section sous rail = section under rail : 614 cm² (95.17 sq. inch).
Moment d'inertie = moment of inertia : 18 874 cm⁴ (785 565 inch⁴).

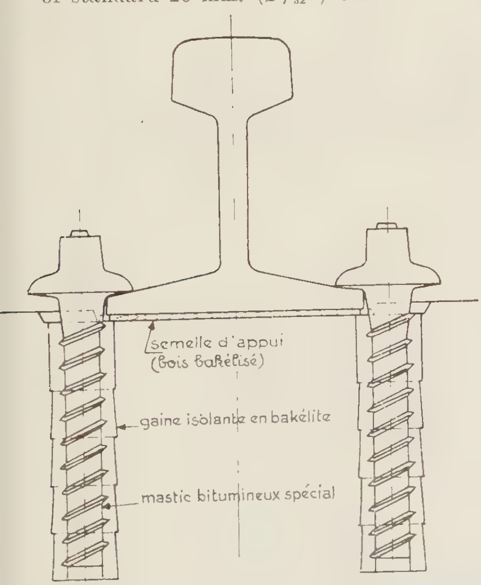
Morocco Railways.

Insulated fastening by means of standard 26 mm. ($1^1/_{32}''$) coachscrew.

Scale : $\frac{1}{4}$.

Algerian Railways.

Fastening by bolt-coachscrew, rigid clip and metal plate.



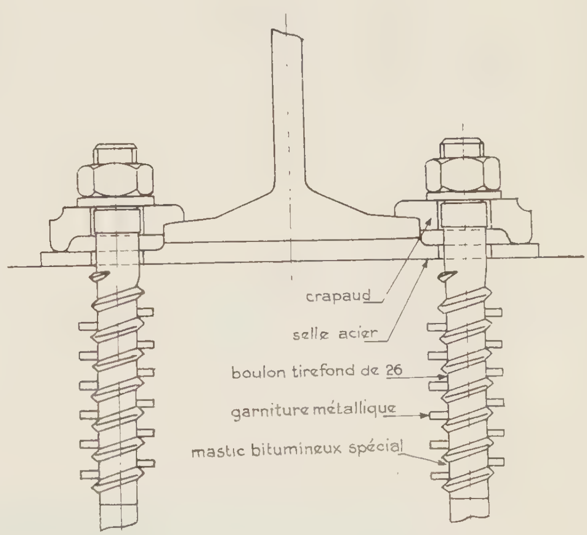


Plate 8. — Combined sleeper in reinforced concrete, Vagneux pattern.

Semelle d'appui (bois bakélisé) = bearing plate (bakelised wood). — Gaine isolante en bakélite = insulated bakelite cover. — mastic bitumineux spécial = special bitumastic compound.

Crapaud = clip. — Selle acier = metal plate. — Boulon tirefond de 26 = 26 mm. bolt-coachscrew. — Garniture métallique = metal fitting. — Mastic bitumineux spécial = special bitumastic compound.

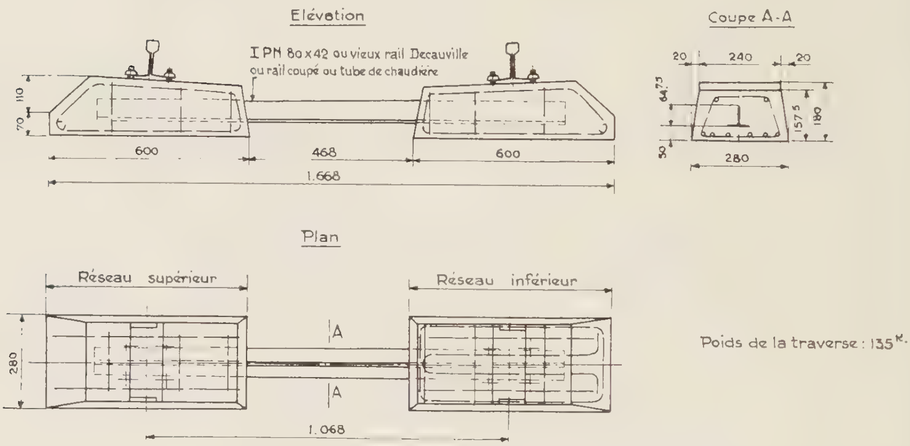
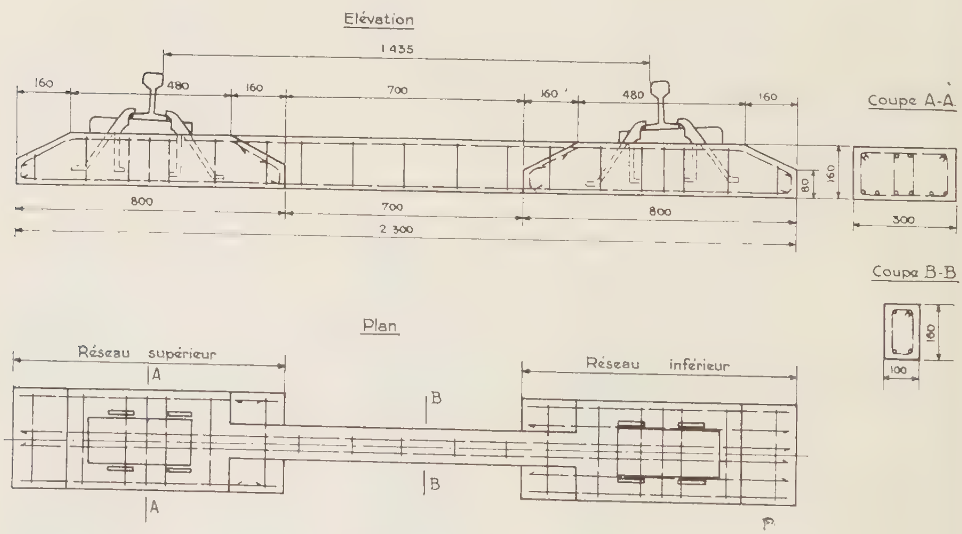


Plate 9. — *Tunisian Railways.* Combined sleeper in reinforced concrete for metre gauge lines.

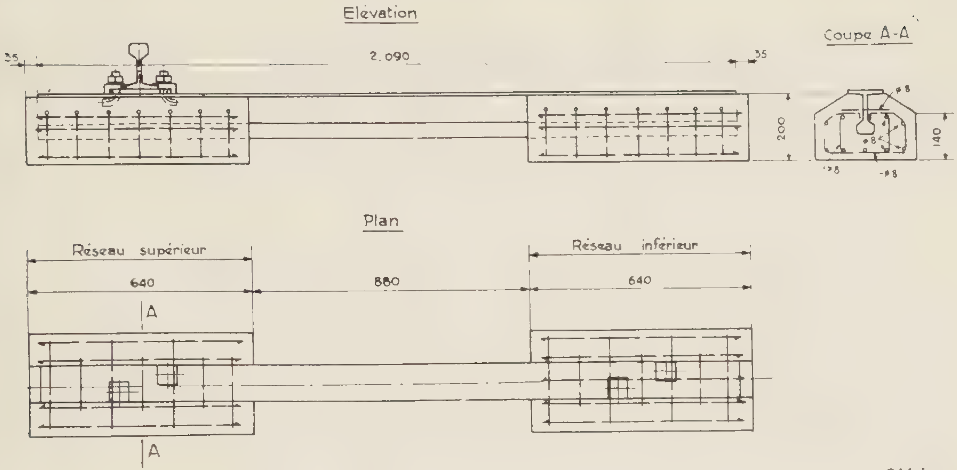
IPN 80×42 ou vieux rail Decauville ou rail coupé ou tube de chaudière = 80×42 IPN channel or old Decauville rail, or cut rail or boiler tube. — Réseau supérieur = No. 1 track. — Réseau inférieur = No. 2 track. Poids de la traverse = weight of sleeper : 135 kgr. (298 lbs.).



Poids de la traverse : 200 kgr.
Section sous rail : 618 cm²
Moment d'inertie sous rail : 7 297 cm⁴

Plate 10. — *Polish State Railways.* Combined sleeper in reinforced concrete.

Poids de la traverse = weight of sleeper : 200 kgr. (440 lbs.).
Section sous rail = section under rail : 618 cm^2 (95.79 sq. inch).
Moment d'inertie sous rail = moment of inertia under the rail : 7 297 cm^4 (303 295 $inch^4$).



Poids de la traverse :	211 kgr.
Poids des aciers (sans l'entretoise) :	9.4 kgr.
Section sous rail :	540 cm²
Moment d'inertie	19 800 cm⁴

Plate 11. — *Netherlands Railways.* Combined sleeper in reinforced concrete.

Poids de la traverse = weight of sleeper : 211 kgr. (464 lbs.).
Poids des aciers (sans l'entretoise) = weight of reinforcement (excluding tie beam) : 9.4 kgr. (21 lbs.).
Section sous rail = section under rail : 540 cm^2 (83.70 sq. inch).
Moment d'inertie = moment of inertia : 19 800 cm^4 (824 107 inch^4).

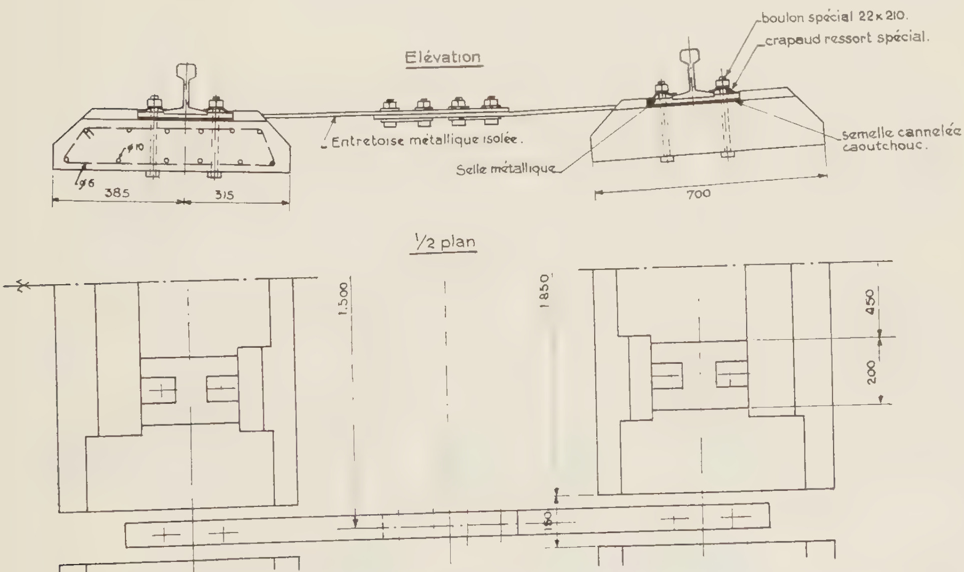


Plate 12. — *French National Railways.* Laval longitudinal sleeper.

Boulon spécial 22×210 = special bolt 22×210. — Crapaud ressort spécial = special spring clip. — Entretoise métallique isolée = insulated metal tie beam. — Selle métallique = metal bearing plate. Semelle cannelée caoutchouc = grooved rubber bearing plate.

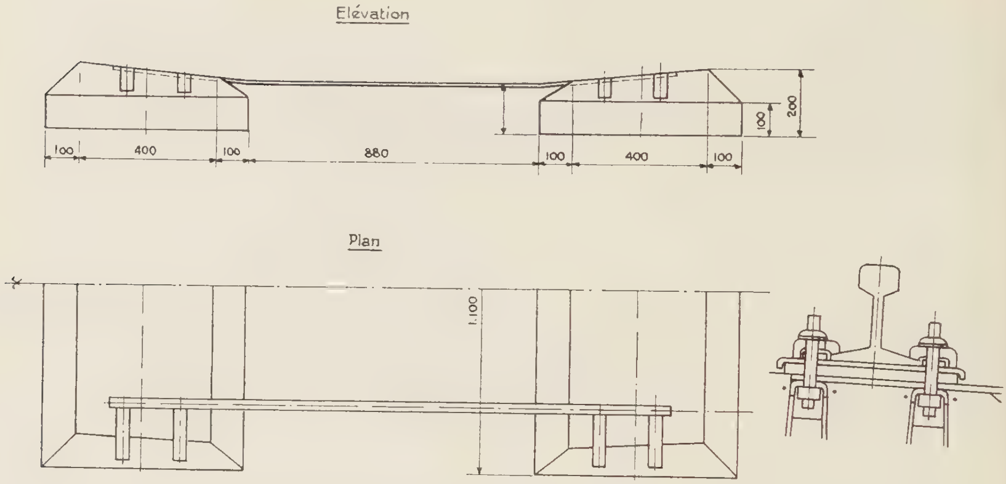


Plate 13. — *Italian Railways.* Valeri longitudinal sleeper (1924-1931).

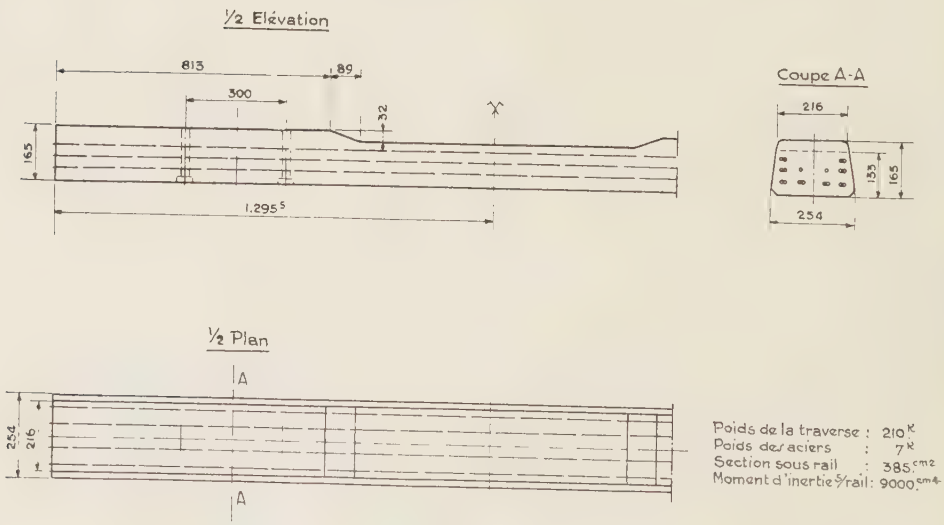


Plate 14. — *Danish State Railways* and *Netherlands Railways.*
Prestressed concrete sleeper SCOP (Dow Mac).

Poids de la traverse = weight of sleeper : 210 kgr. (462 lbs.).
Poids des aciers = weight of reinforcement : 7 kgr. (15 lbs.).
Section sous rail = section under rail : 385 cm^2 (59.675 sq. inch).
Moment d'inertie sous rail = moment of inertia under rail : 9 000 cm^4 (374 569 inch^4).

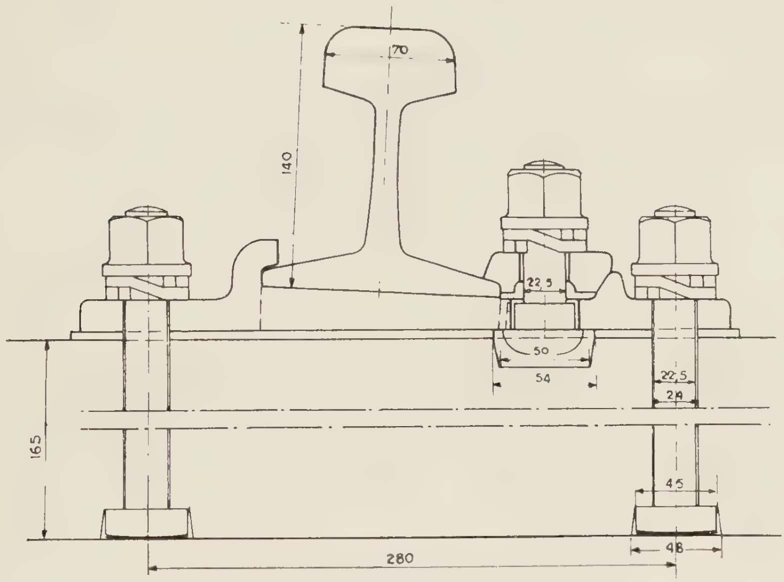


Plate 15. — *Danish State Railways.*
Rail fastening on Dow Mac prestressed concrete sleeper. Scale : $\frac{1}{4}$.

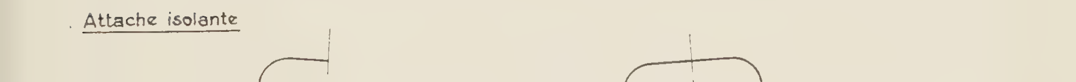


Plate 16. — *Netherlands Railways.*
Rail fastening on prestressed concrete Dow Mac sleeper. Scale : $\frac{1}{4}$.
Attache isolante = insulated fastening. — Rondelle en acier = steel washer. — Rondelle isolante en caoutchouc = insulating rubber washer. — Semelle caoutchouc = rubber bearing plate. — Canon en bois = wooden barrel.

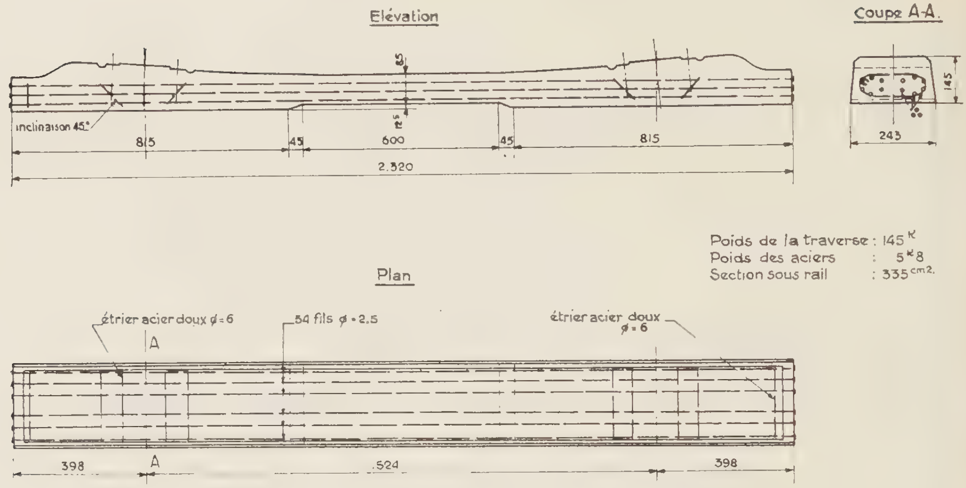


Plate 17. — *French National Railways.* SCOP prestressed concrete sleeper (FREYSSINET method).

Etrier acier doux = mild steel strap. — 54 fils = 54 wires.
Poids de la traverse = weight of sleeper : 145 kgr. (319 lbs.).
Poids des aciers = weight of reinforcement : 5.8 kgr. (13 lbs.).
Section sous rail = section under rail : 335 cm² (51.925 sq. inch).

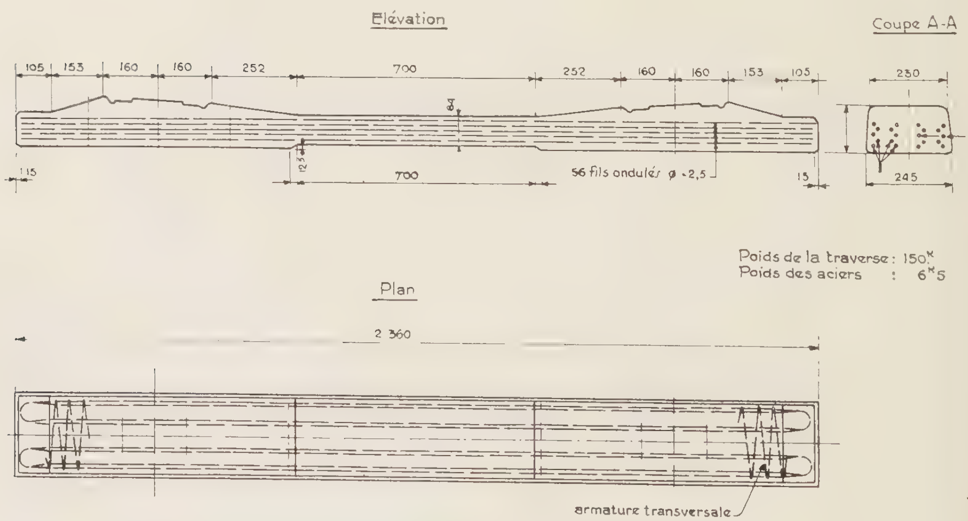


Plate 18. — *French National Railways.* Brignoud STUP sleeper of prestressed concrete.

56 fils ondulés = 56 wavy wires. — Armature transversale en spirale = tranversal spiral reinforcement.
Poids de la traverse = weight of sleeper : 150 kgr. (330 lbs.).
Poids des aciers = weight of reinforcement : 6.5 kgr. (14 lbs.).

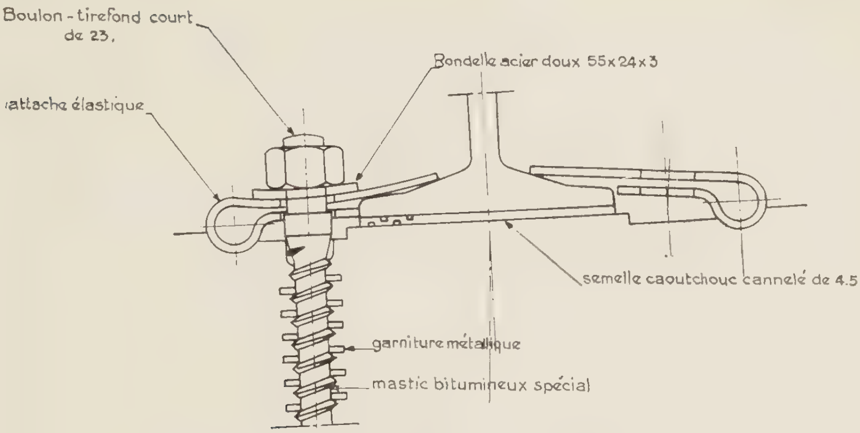


Plate 19. — *French National Railways.*
Elastic fastening for prestressed concrete sleepers. Scale : $\frac{1}{4}$.

Boulon-tirefond court de 23 = short 23 mm. (29/32") bolt coachscrew. — Attache élastique = elastic fastening. — Rondelle acier doux 55×24×3 = mild steel washer 55×24×3. — Semelle caoutchouc cannelé de 4.5 = grooved rubber bearing plate 4.5. — Garniture métallique = metal fitting. — Mastic bitumineux spécial = special bitumastic compound.

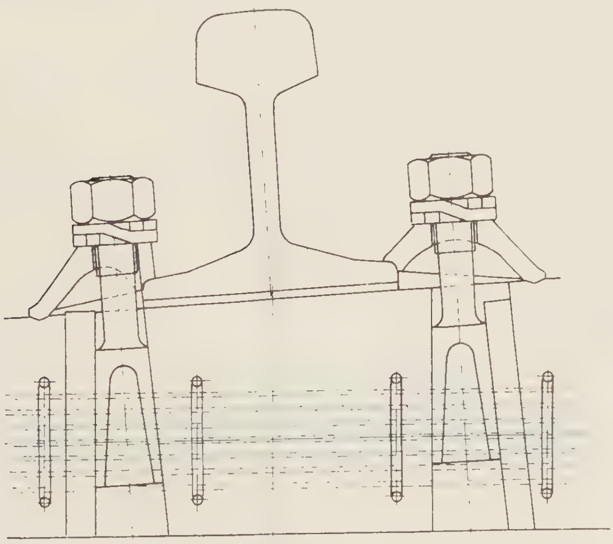


Plate 20. — *French National Railways.*
Fastening for STUP FP23 sleeper (tried out in 1945).
Scale : $\frac{1}{4}$.

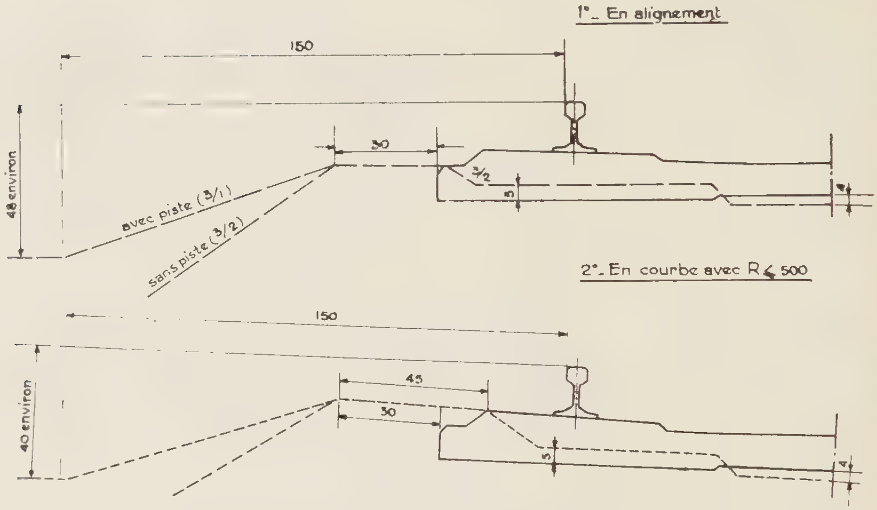


Plate 21. — *French National Railways.*
Typical section of ballast with prestressed concrete sleepers.

1° En alignement = 1. On the straight. — 48 environ = about 48. — Avec piste (3/1) = with track (3/1). — Sans piste (3/2) = without track (3/2). — 2° En courbe avec R ⩽ 500 = 2. On curves of radius R ⩽ 500.

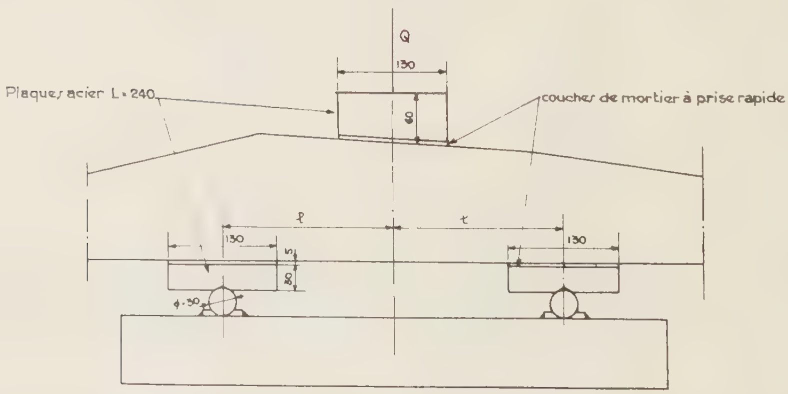


Plate 22. — *French National Railways.* Arrangement for testing sleepers.

Plaques acier L = 240 = steel plates L = 240.
Couches de mortier à prise rapide = layer of quick setting mortar.

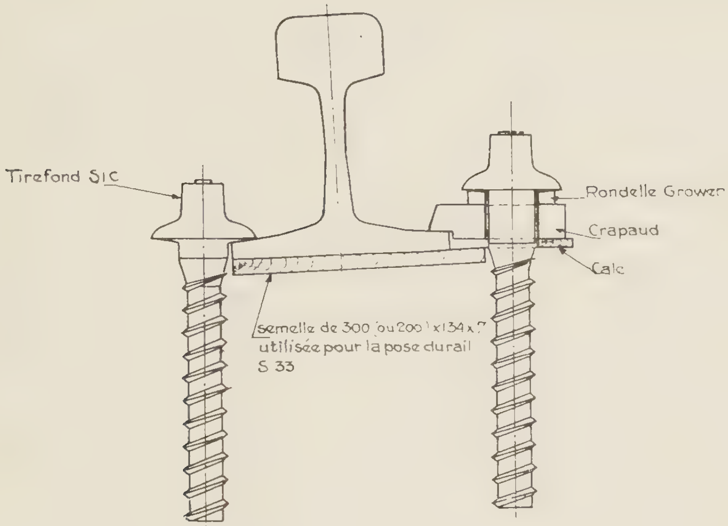
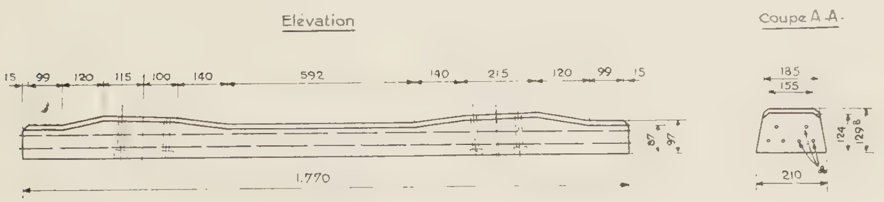
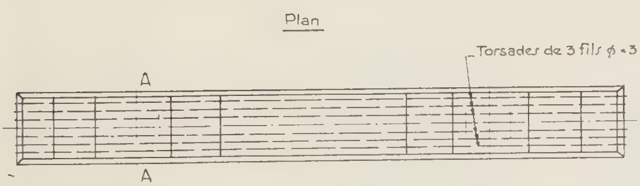


Plate 23. — *Morocco Railways.* Fastening by means of coachscrews and clips (for rails with smaller flat base). Scale : $\frac{1}{4}$.

Tirefond SIC = SIC coachscrew. — Rondelle Grower = Grower washer. — Crapaud = clip. — Cale = wedge. — Semelle de 300 (ou 200) × 134 × 7 utilisée pour la pose du rail S.33 = plate 300 (or 200) × 134 × 7 used for laying the S.33 rail.





Poids de la traverse : 90 K.
Poids des aciers : 2 K.

Plate 24. — *French West African Railways.*
STUP prestressed concrete sleeper for metre gauge track.

Torsades de 3 fils Ø 3 = 3 Ø 3 wires twisted together.
Poids de la traverse = weight of sleeper : 90 kgr. (198 lbs.).
Poids des aciers = weight of reinforcement : 2 kgr. (4.4 lbs.).

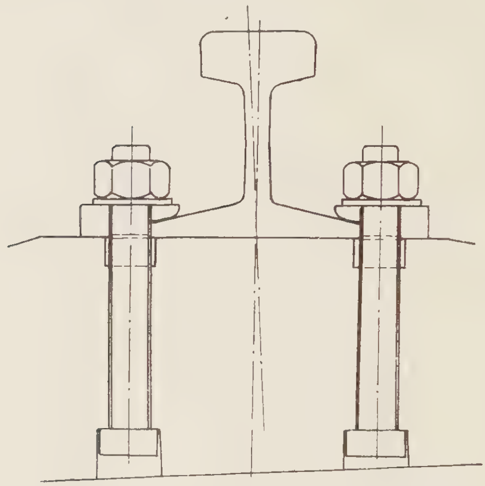


Plate 25. — *French West African Railways.*
Direct fastening on STUP sleeper. Scale : $\frac{1}{4}$.

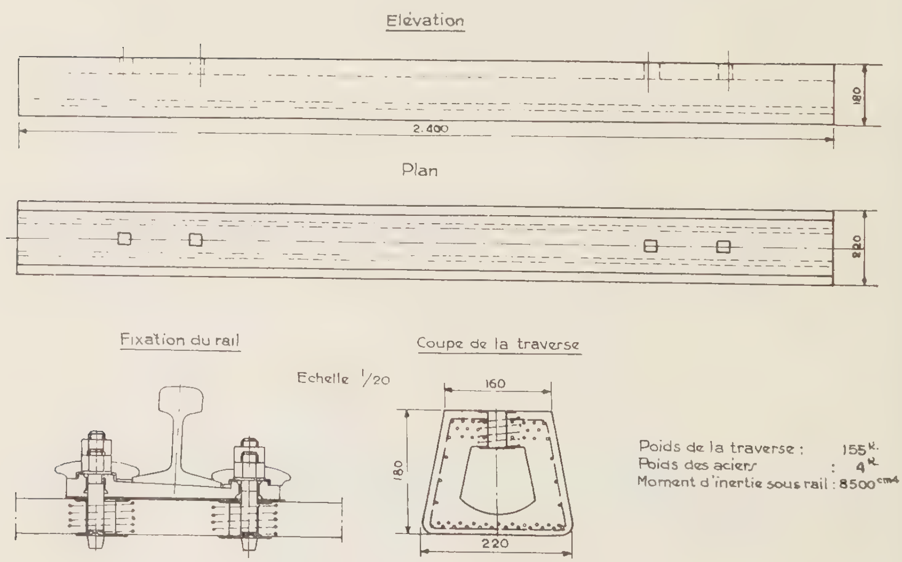
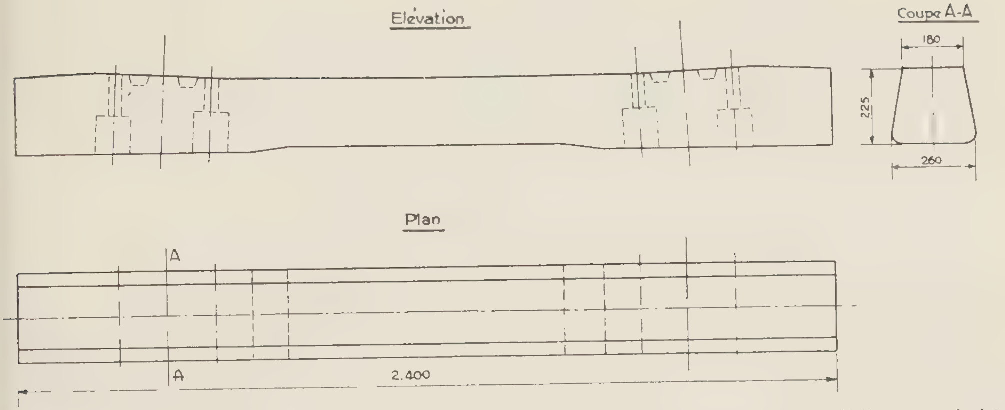


Plate 26. — *Italian Railways.* SCAC prestressed concrete sleeper.

Fixation du rail = rail fastening. — Coupe de la traverse = sleeper section. — Echelle : 1/20 = scale : 1/20.
Poids de la traverse = weight of sleeper : 155 kgr. (341 lbs.).
Poids des aciers = weight of reinforcement : 4 kgr. (8.8 lbs.).
Moment d'inertie sous rail = moment of inertia under rail : 8 500 cm^4 (353 783 $inch^4$).

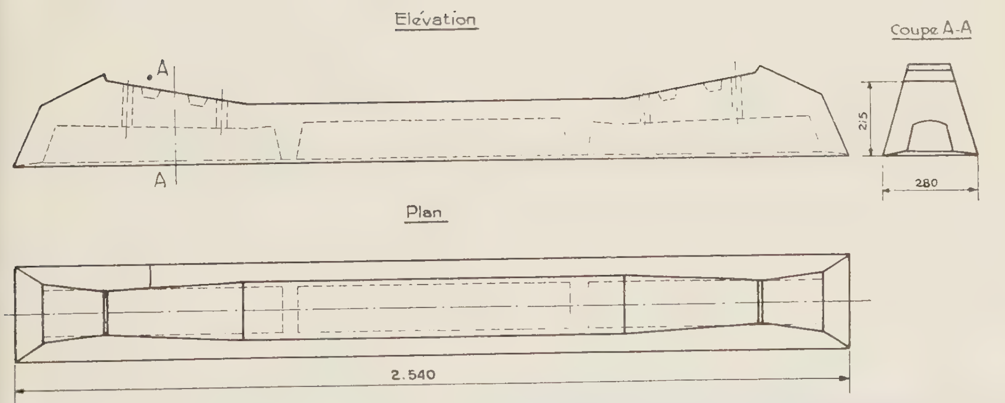


Weight of sleeper : 280 kgr. (617 lbs.)
Weight of reinforcement : 3.7 kgr. (8 lbs.)

Prestressing of concrete { upper limit 79 kgr./cm² (1 123 lbs. per sq. inch.)
lower limit 100 kgr./cm² (1 422 lbs. per sq. inch.)

Plate 27. — *Swiss Federal Railways.*

Type I prestressed concrete sleeper put into service in April 1944.

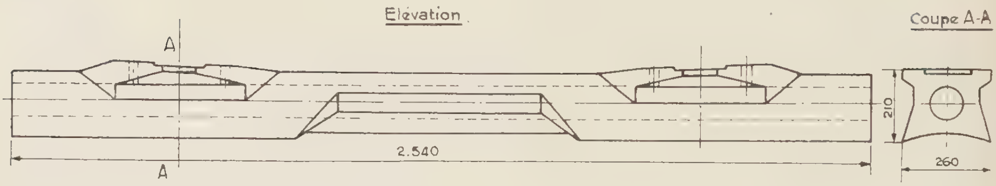


Weight of sleeper : 160 kgr. (352 lbs.)
Weight of reinforcement : 4 kgr. (8.8 lbs.)

Prestressing of concrete under the rail { upper edge 15 kgr./cm² (213 lbs. per sq. inch.)
lower edge 268 kgr./cm² (3 811 lbs. per sq. inch.)

Plate 28. — *Swiss Federal Railways.*

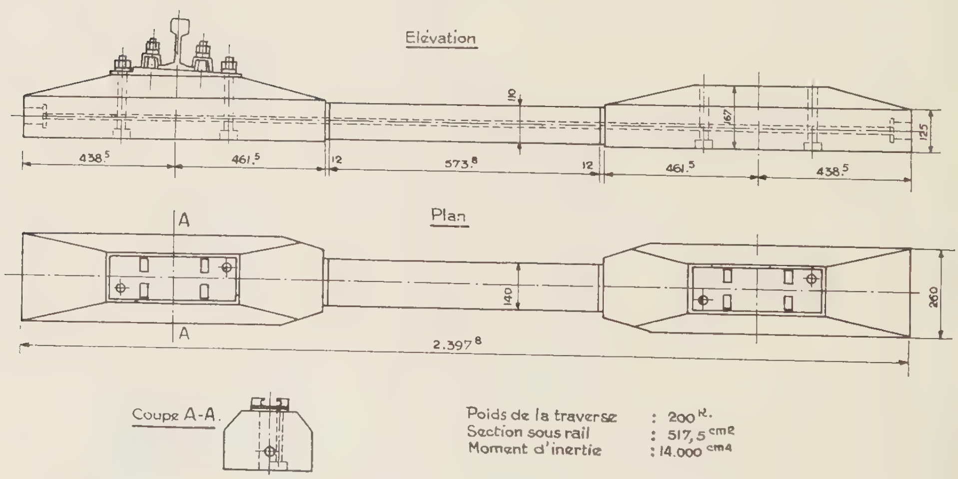
Type II prestressed concrete sleeper, put into service in June 1945.



Weight of sleeper : 180 kgr. (397 lbs.)
Reinforcement (wires Ø 3.)

Prestressing of concrete under the rail:
- upper edge 30 kgr./cm² (426 lbs. per sq. inch.)
- middle of the sleeper 135 kgr./cm² (1 920 lbs. per sq. inch.)
- lower edge 120 kgr./cm² (1 706 lbs. per sq. inch.)

Plate 29. — *Swiss Federal Railways.*
Type III prestressed concrete sleeper, put into service in March 1946.



Poids de la traverse : 200 K.
Section sous rail : 517,5 cm²
Moment d'inertie : 14.000 cm⁴

Plate 30. — *Belgian National Light Railways.* Franki-Bagon sleeper.

Poids de la traverse = weight of sleeper : 200 kgr. (440 lbs.).
Section sous rail = section under rail : 517.5 cm² (80.21 sq. inch).
Moment d'inertie = moment of inertia : 14 000 cm⁴ (582 702 inch⁴).

[**656** .225 & **656** .261]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

ENLARGED MEETING OF THE PERMANENT COMMISSION
(LISBON, 1949.)

QUESTION III.

Transport of miscellaneous goods.

Concentration in a certain number of selected centres (stations) of miscellaneous traffic, transport by rail between centre-stations, by road or rail between the originating point and the nearest centre-station, and also to the last centre-station near the destination.

Interest of the scheme for the conveyance of goods traffic.

Organisation of the station-centres and of the collection and delivery services.

Financial results of the scheme.

REPORT

(America, Great Britain, Dominions, Protectorates and Colonies, Burma, China, Egypt, India and Pakistan),

by P. H. SARMA,

Director of Wagon Interchange and General Secretary, Indian Railway Conference Association, India.

INTRODUCTION.

A detailed list of questions was drawn up by M. Moulart and the Reporter and sent to 25 different Railway systems. Replies were received from :

British Railways,
Pennsylvania Railroad and Long Island Railroad,
Indian Railways,
Pakistan Railways,
Iraq Railways,
Burma Railways,
New Zealand Railways,
East African Railways & Harbours,
Sudan Railways,
Nigerian Railways,
Egyptian State Railways,
South African Railways.

Complete replies were received from the British Railways and Pennsylvania Railroad & Long Island Railroad.

New Zealand Railways and East African Railways & Harbours gave general features of their system of working in regard to the questions under reference, while the other Railways which were addressed expressed their inability to give detailed answers. On many Railways the problems envisaged in the questionnaire do not occur as the industrial development and operating conditions prevailing are not

of the same order as in countries like Great Britain and America. Consequently, the answers received cover only a few of the questions raised.

The questionnaire included transport of small lots by parcels and postal mails besides movement by goods train services. Except in the case of the British Railways, answers given were confined to transport by goods trains. Postal parcels in many countries are transported under the ægis of the Postal Department under definite arrangement. No mention has been made of any special organisations on the Railways for the transport of such traffic.

The Reporter would like to convey his thanks to his colleagues on the various Railways for the time and care they have devoted in preparing their replies.

CHAPTER I.

Acceptance of smalls.

The acceptance of miscellaneous goods in less than carload shipments (small lots), in regard to their nature, volume and weight, is free in all countries except in respect of packages of extraordinary size and length.

In Great Britain, India and other countries which have adopted laws similar to those in Great Britain, the Railways, in general, are « common carriers » which means that with certain specified exceptions, they are under an obligation to accept all traffic tendered for conveyance and are fully responsible for the safe custody and protection of the goods whilst in transit. Their legal liability is, however, modified slightly by standard terms and conditions of carriage.

Briefly, the Railways accept full liability for loss, damage or misdelivery unless it can be proved that it was due to specified causes such as Act of God, Act of War or the King's Enemies, acts of the sender or his agents, inherent vice, fire or explosion. Even in these cases, however, the Railways must prove that reasonable care and foresight has been exercised. The Railways are also relieved of all liability for certain specified articles, if their value exceeds a certain specified amount unless these have been specifically declared and increased charge paid to cover insurance.

In many cases the Railway offers to carry traffic at reduced Owner's risk, in consideration of the sender accepting risk of damages, misdelivery or detention not caused by wilful misconduct of the Railway or its servants. Livestock and damageable goods not properly protected by packing are also the subject of qualified liability, while explosives and dangerous chemicals are only accepted on the basis of a special contract with modified liability according to the nature of the article. Senders generally have the option, on payment of a proper charge, to dispatch goods by express goods or passenger train services, the latter subject to maximum weight per package, normally providing faster transit and earlier delivery.

On Indian Railways, in view of the increased demand for transport, certain temporary measures have been taken to restrict acceptance of L.C.L. consignments with a view to conserving wagons for full wagon load traffic. Stations have been given limited quotas by weight for acceptance of L.C.L. consignments.

All loading operations are performed by Railways.

Booking of goods.

The sender or his agent makes out a consignment note which forms the basis of the legal contract between the Railway and the sender. Various forms of consignment notes are in use, Car-

rier's risk, Owner's risk, dangerous goods, inflammable liquids, etc., according to the nature of the traffic and Railway regulations. Tranship documents, known as goods invoices, containing full information as to the sender, consignee, number of packages, weight, delivery and other conditions are made out by the forwarding station for the purpose of affording necessary check and delivery of the full number of articles. A copy of this is also handed over to the sender which has to be tendered at the delivery point to enable the consignee to collect his consignment.

Parcels traffic which is carried by passenger trains is similarly way-billed on many Railways, but on the British Railways they are not normally way-billed, the particulars being afixed to each parcel to indicate that the charges have been or will have to be collected from the sender.

Charges are raised on weight, classification and mileage basis. The minimum chargeable weight is laid down according to the various conditions prevailing in different countries. The General Classification of Goods or Merchandise gives the details of the classification of different commodities. On the British Railways, special general classification is provided for small lot consignments.

Considerations of weight, classification and mileage also arise for the charging of parcels by express service, but, in some cases, charges are raised on a simple mileage scale according to weight.

The maximum weight of individual packages for acceptance by passenger or parcels train service has also been laid down by different Railways.

Many Railways do not make any distinction between L. C. L. goods conveyed by express freight train and those by ordinary goods service.

There is no distinction corresponding to the French « Régime Accéléré » or « Régime Ordinaire », although parcels are moved as expeditiously as possible — no guarantee of delivery by any day or time is given. The main obligation of the Railways is to give reasonable dispatch.

Both in Great Britain and America, the freight charges levied include collection and delivery services, while in other countries, additional charges are made over and above the haulage charges over rail.

Home collection and delivery services.

Home collection and delivery services are extensively provided in Great Britain and America while these are confined to important towns in India, Egypt and South Africa. The conditions of acceptance by home collection and delivery services are the same as described before. In Great Britain, America and South Africa, home collection and delivery services wherever provided are normally given to « smalls » traffic unless otherwise declined by senders and the transport charges quoted are inclusive of the service. The organisation of the service is given in detail later in the report.

Forwarding stations.

The initial equipment at the forwarding stations, where collection and delivery arrangements are provided, is generally a covered shed consisting of specified bays for different directions with a raised deck or platform, the height of which is approximately the same as the floor of a Railway wagon with facilities for berthing road and rail vehicles. The goods are conveyed across the platform from rail to road vehicle and vice versa by wheeled hand barrows or by manual labour.

At some of the larger depots in Great Britain, power trucks with or without

trailers are utilised and at a few modern stations conveyors are employed.

At many stations forwarded traffic is loaded direct to a Railway wagon, the road vehicle perambulating from one wagon to another until the load is disposed of.

An ideal layout for Railway station premises in large towns, where sufficient amount of parcels traffic has to be dealt with should include platforms and should be separate, but contiguous to the passenger station. Separate forwarded and received accommodation should be provided with access where possible to subsidiary road. The accommodation should be covered and afford shelter to road and rail vehicles during loading and unloading operations. Also a deck should be provided at floor level of cartage vehicles to facilitate handling of the traffic. Convenient connection with other platforms should be provided to enable traffic for specific passenger train services to be hauled to the appropriate departure platform for dispatch.

Organisation.

Consignments are collected from senders either by Railway cartage vehicles or by senders' own transport up to the goods depot for dispatch. These are sorted out destinationwise. Through wagons direct to destinations are made out where the total weight of such consignments conforms to the prescribed minimum laid down. Different Railways have detailed the minimum according to the prevailing conditions of traffic in relation to the carrying capacity of the wagons on their systems. On the British Railways a minimum of 1 ½ tons and, in some cases, 1 ton has been laid down; on the American Railways the minimum is 10 tons; on the Indian Railways Broad Gauge (5′-6″ gauge) 4 ½ tons and Metre Gauge (3′-3 3/8″) 3 tons; on Egyptian State Railways 3 tons; and on Iraq Railways 3 tons. Where the volume of traffic for a particular destination is insufficient to justify dispatch of a through wagon, it is loaded in a wagon to an intermediate point for transhipment along with traffic for traders at such town, which is normally the point at a reasonable distance of the ultimate destination.

Packages are all loaded to the farthest transhipment points, thus eliminating, as far as possible, handlings at intermediate tranship points.

On Iraq, Egyptian, Indian and Pakistan Railways goods which are considered to be dangerous, explosive or offensive are loaded in separate wagons.

Wagons with separate compartments for L. C. L. shipments from one station to another are not in use. Where more than one wagon of miscellaneous traffic is sent from one station to another, separate wagons are made for town traffic (for delivery by the station concerned) and the tranship traffic (for further rail transit) separately.

Wagons for tranship points are dispatched either by express trains or by ordinary trains according to the volume of traffic handled at the station.

L. C. L. consignments from a terminus to the first tranship point are loaded in « tariff vans » or « pick-up vans » from and to a tranship station on a scheduled service calling at specified stations which take out consignments addressed to them and put in consignments for dispatch.

The method of organisation for clearance of parcels traffic is more or less similar. Where sufficient traffic is available, through vans are scheduled direct to destination, but where the volume of traffic does not warrant full use of a Railway vehicle, one van serves stations on the route of the train. These vans are cleared daily by scheduled passenger or parcel trains. Transit

arrangements for parcels traffic are always under review to meet changing conditions and to ensure operational efficiency with economy.

Tranship points.

Tranship stations are usually selected, giving due consideration to the volume and direction of traffic, junction facilities and train services. On many Railways they have developed as Railways have grown. In Great Britain and America very few tranship stations exclusively work as such. Therefore, rail and road access to the tranship platforms have been found essential for the purpose of dealing with the originating or delivery traffic and tranship traffic. In other countries, they function exclusively as tranship points and, in many cases, road facilities do not exist. The sizes of the platforms vary from 5 to 30 wagon lengths, tracks are provided on either side of the platform specially where the tranship points do not deal with road traffic. On the South African Railways, consideration is now being given to the provision of spurs, taking off from the main line to provide for flexibility in working.

The organisation of tranship stations on British Railways is interesting and is given in extenso :—

It has been established that the nature of received « L. C. L. » traffic varies little on average between one station and another. Forwarded « L. C. L. » traffic is mainly composed of the output of local manufacturers and may therefore vary from place to place.

Recent practice is for forwarded traffic to be loaded direct from cartage vehicle to appropriate Railway wagons placed on one or more sidings, under cover, set aside for the purpose, by means of perambulation, no deck being interposed.

With regard to received traffic, present policy is to introduce mechanisation at stations where such tonnage exceeds 40 tons per day.

Two diagrams are attached illustrating

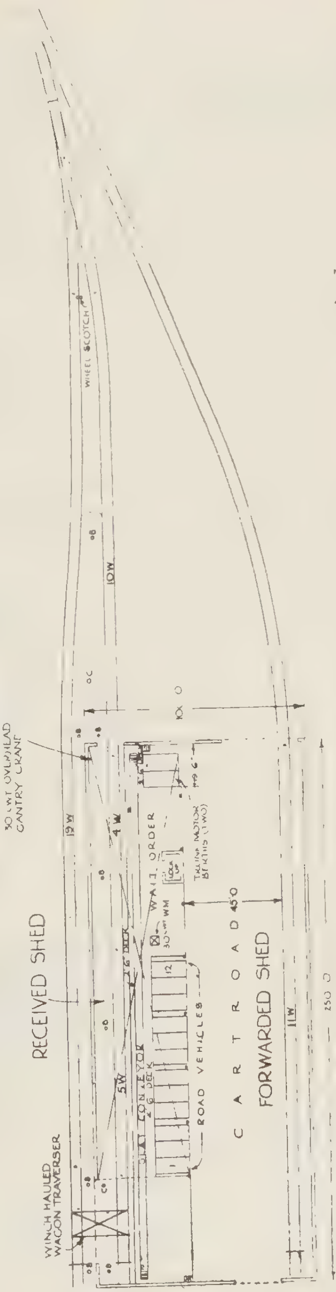
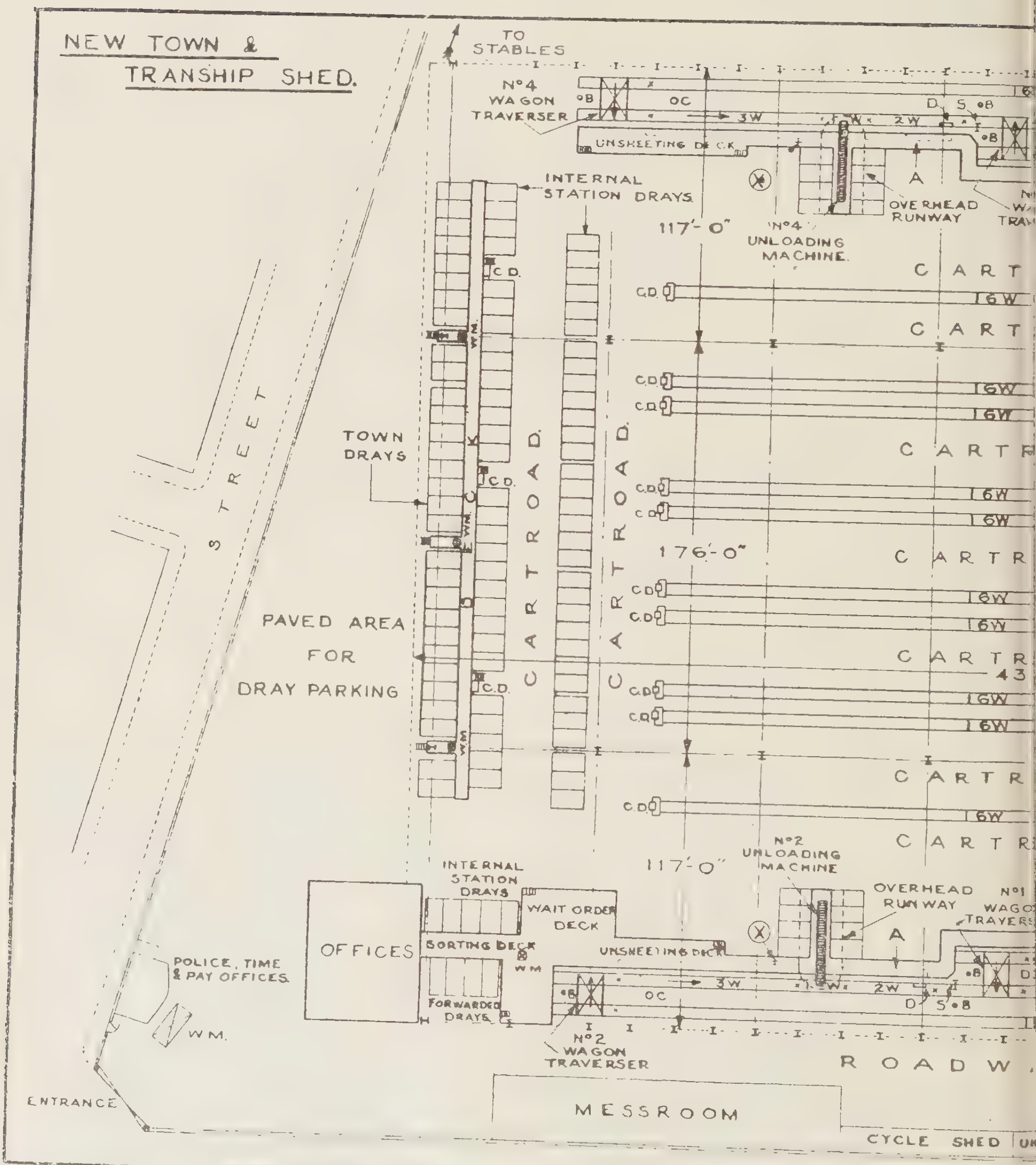


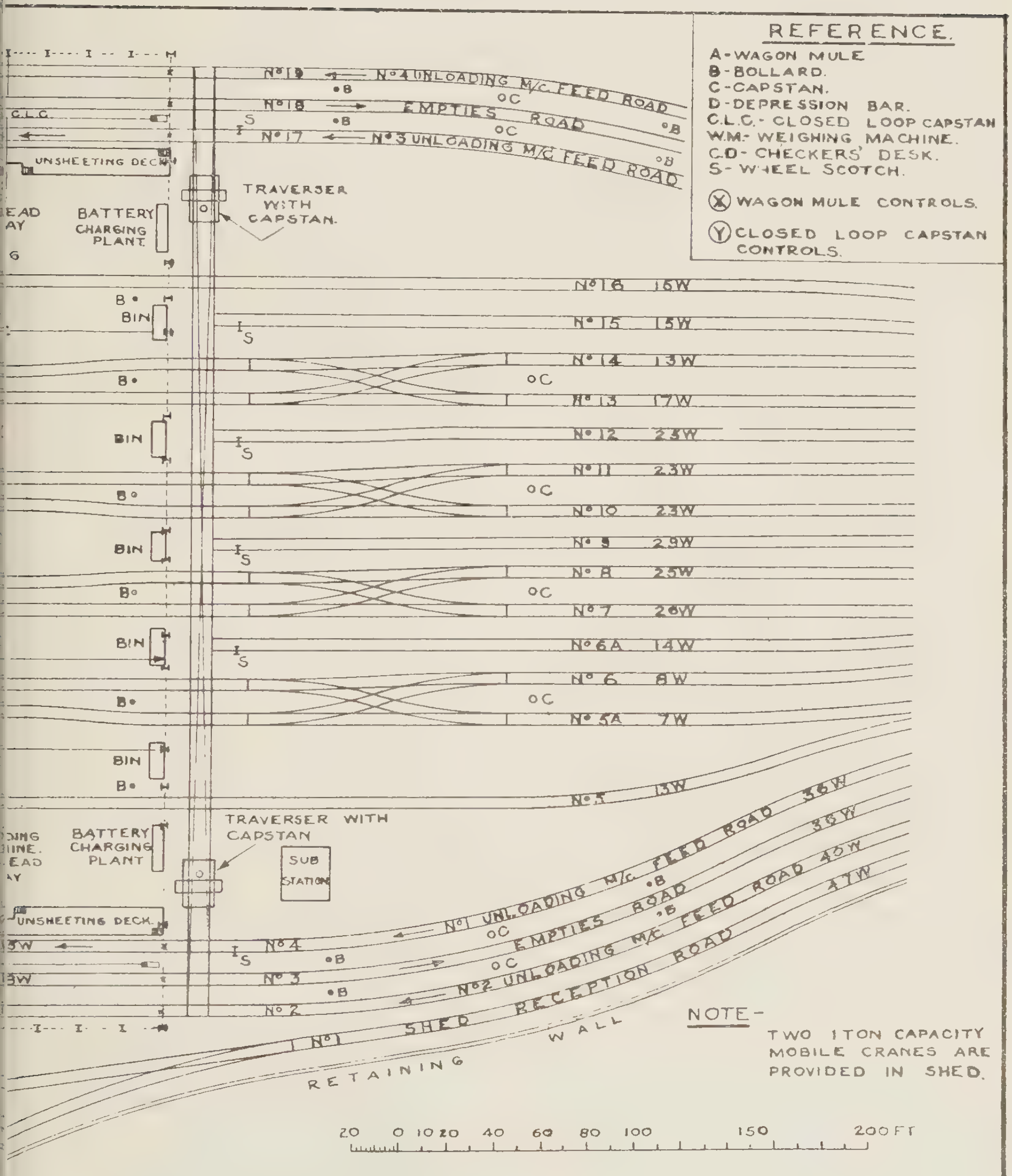
DIAGRAM 1.

British Railways. — Lay-out of a goods shed designed to cater for daily tonnages varying from 40 to 150 tons.

Notes. Separate warehouse accommodation to be provived if required
Adequate natural and artificial lighting to be provided.
Capstan paving where necessary.
Mobile crane to be provided for forwarded shed.
Shed to be provided with doors as necessary.
°C denotes Capstan (fixed head type).
°B denotes Bollard (fairlead dummy).
W.M. denotes weighing machine.



British Railways.


REFERENCE.
A-WAGON MULE.
B-BOLLARD.
C-CAPSTAN.
D-DEPRESSION BAR.
C.L.C.- CLOSED LOOP CAPSTAN
W.M.- WEIGHING MACHINE.
C.D- CHECKERS' DESK.
S- WHEEL SCOTCH.
(X) WAGON MULE CONTROLS.
(Y) CLOSED LOOP CAPSTAN CONTROLS.
N°4 UNLOADING M/C FEED ROAD
EMPTIES ROAD
N°3 UNLOADING M/C FEED ROAD
UNSHEETING DECK
TRAVERSER WITH CAPSTAN.
BATTERY CHARGING PLANT
N°16 15W
N°15 15W
N°14 13W
N°13 17W
N°12 23W
N°11 23W
N°10 23W
N°9 29W
N°8 25W
N°7 26W
N°6A 14W
N°6 8W
N°5A 7W
N°5 13W
TRAVERSER WITH CAPSTAN
SUB STATION
N°1 UNLOADING M/C FEED ROAD
EMPTIES ROAD
N°2 UNLOADING M/C FEED ROAD
SHED RECEPTION ROAD
RETAINING WALL
NOTE-
TWO 1 TON CAPACITY MOBILE CRANES ARE PROVIDED IN SHED.
20 0 10 20 40 60 80 100 150 200 FT

r goods shed.

modern ideas on the mechanisation and layout of goods sheds, both arrangements having been in service several years.

Diagram 1 depicts a layout designed to cater for daily tonnages varying from 40 tons to 150 tons of received traffic for delivery in the locality. This layout would also be satisfactory for tranship traffic not exceeding 10 % of the total.

Incoming traffic is unloaded from wagon to « slat » conveyor at deck level which takes the packages to the road vehicle berths where they are placed on the appropriate vehicle and checked. Tranship traffic would be initially dealt with in similar manner, the road vehicles afterwards being perambulated alongside wagons on the forwarding siding for direct loading thereto.

An overhead gantry crane enables heavy articles to be transferred direct from wagon to road vehicle.

Wagons after discharge are transferred by capstan and traverser to the empty wagon siding outside the building.

An existing goods shed of this type deals with an average of 53 tons per day at a speed of 0.77 man hours per ton.

Diagram 2 illustrates the layout of a much larger goods shed dealing primarily with a daily average of 450 tons of tranships, but also catering for 100 tons of received traffic and 45 tons of forwarded traffic at 1.68 man hours per ton overall based on « machine » weight.

In this case the inward wagons are fed by capstan individually to each of four unloading machines, where contents are sorted eight ways on to internal drays, i. e., which do not go outside the station.

Each loaded internal dray is then taken either to one of the five outward sections in the case of tranships for loading into railway wagons set in position; or, if containing town traffic to one of the three sections of the cart front where road vehicles are loaded for delivery.

Each of the five outward loading sections accommodates 32 wagons, making a total of 160 possible different wagon destinations; each of the town delivery loading sections holds 10 road vehicles making a total of 30.

There is thus a preliminary breaking down of the traffic into eight sorts, and a final disposal to 190 different loadings.

It will be seen that tranship traffic is perambulated from wagon to wagon in the outward loading section, and transferred direct from internal dray to the appropriate wagons. Internal drays carrying traffic for delivery in the town are placed at the narrow deck called the « cart front » across which goods are checked and loaded to delivery vehicles.

Each wagon unloading machine is provided with an overhead crane for dealing with heavy articles, and mobile cranes effect the final transfer of such heavy articles from internal dray to wagon or delivery vehicle.

An unloading machine consists of a power-operated rubber belt conveyor plus an extension of free rollers, the whole mounted on wheels enabling the machine to be thrust into the wagon doorway. Goods are placed on the moving belt by wagon discharging staff, and on reaching the rollers are transferred by sorting staff to the appropriate internal dray.

The internal drays transport bulk loads of 20-25 cwts. thus reducing the number of journeys required under the old method of trucking by hand-barrows with loads of $\frac{3}{4}$ cwts. to 2 cwts.

As in the case of Diagram 1, the loading of forwarded traffic is generally done direct from road vehicle to wagon without having to pass over a deck. Provision is made however for large loads of numerous consignments to be sorted over a deck from collection vehicle to internal drays for perambulation in the appropriate section of forwarded wagons.

Most of the large goods stations in this country are situated in the centre of built up areas, where it is not practicable to acquire land for extension. In such cases the degree of modernisation must be adopted to the circumstances, but the main principles of mechanisation remain viz. :

(*a*) Bring traffic to the man rather than vice versa.

(*b*) Move goods in bulk from point to point.

(*c*) Eliminate hand barrowing.

(*d*) Provide cranage as necessary.

On the Pennsylvanian Railroad & Long Island Railroad both loading and unloading trucks are given through

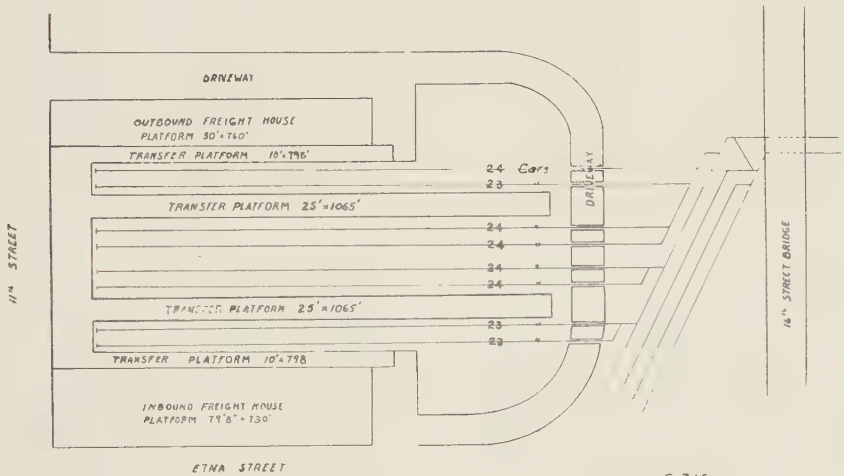
access to the wagons on the platform. Platforms are also provided so that lorries may be loaded or unloaded without interfering with the handling of wagons.

A typical American station diagram is also attached.

Working of tranship stations.

On the British Railways and the Pennsylvanian Railroad & Long Island Railroad, tranship work continues throughout the day and night, while on other Railways where the volume of traffic is not heavy, the work is principally confined to day light only. Each package is checked with the transport document by Railway staff and is loaded in through wagons provided the prescribed minimum weight is obtained. Packages for the farthest tranship points are loaded along with packages for intermediate station or the nearest tranship point in tariff or road vans. Packages are sorted in order to get as many direct wagons as possible.

At tranship points empty wagons are also placed for loading at the same time as loaded ones. The number of empty wagons placed varies according to the volume of traffic handled and limitation of platform accommodation of the tranship stations. Consignments are dealt with the same day they are received. Almost all the tranship points are served by at least two connecting trains from and to each direction. On British Railways, daily services connect up all principal towns and most of the main tranship stations giving a one-day transit from point to point. On the Pensylvanian Railroad & Long Island Railroad, the daily number of cars used is 2 259, average load being 7.6 tons per car and the average daily distance covered by the same is 48.8 miles.



American Railways.

A typical station diagram.

On the British Railways, large goods stations deal with both tranship as well as town traffic. Inward wagons of L. C. L. traffic arrive from 10 p.m. onwards throughout the night. It is the practice to discharge them as early as possible after positioning in the shed, the majority of such wagons containing traffic for delivery in the town as well as for transhipment. It is their aim and object to deliver the goods from early morning.

The average daily out-put per man varies very considerably between stations and is dependent on the volume of traffic and the range of destinations, capacity of shed and the mechanical aids provided at the tranship points and daily variation in the flow of traffic. The following figures would be of interest :—

On the Pennsylvania Railroad & Long Island Railroad, the daily average output of transhipment traffic handled is 13 212 tons and 45 out of every 100 shipments are transhipped. On the British Railways, the daily output per man-hour averages 1.68 tons and the average weight per consignment which may comprise more than one package is about 2 cwts.

Use of containers.

Containers are not generally used anywhere for tranship traffic. On the British Railways L. C. L. consignments loaded in a container are considered a full wagon load and charged as such. On the Egyptian Railways, containers are used for transporting household furniture only and these are owned by the Railways. On the Pennsylvania Railroad & Long Island Railroad, containers are used in 75 per cent. cases. They are made of cardboard or wooden boxes, cans, drums and barrels. These belong to the senders. Tariff charges are made on the gross weight, that is, including the weight of the container. They are usually returned by consignees on payment of regular charges. No containers are used at tranship points for forwarding shipments which do not arrive in containers. From the Railway point of view, the use of containers reduces considerable loss and damage and permits faster and easier handling.

CHAPTER II.

Road carriers.

The majority of the road carriers in almost all the countries perform their own collection and delivery services. The road services operate under a license which restricts them as to the distance and, in some places, as to commodities as well.

There is no control on road carriers in so far as the scale of tariffs is concerned, but some observe the scales prescribed and issued by Road Carrier Companies. The majority of them pick and choose their own traffic and in practice are restricted only, in certain countries, to loads and weights beyond which they must not load their vehicles. In some countries Road Carriers are prohibited from entering into an uneconomical competition with the Railways and measures are taken to ensure co-ordination between road and rail. In Great Britain, the long distance road haulage industry is governed by the Transport Act of 1947 and will, in due course, operate under the executive control of the British Transport Commission. Very few Railways have experience of Collection Companies as is known in America and Europe. The Pennsylvanian Railroad & Long Island Railroad's report on this specific question is quite interesting. They consider that the part played by the Collection Companies is profitable as far as utilisation of rolling stock and handlings on Railway installations are concerned. Collection Companies are allowed regular carload freight rates. They consider

that it is rather doubtful whether tariff reduction allowed is compensated by a reduction in the operating expenses. Possibility exists of Collection Companies taking advantage of a particular favourable situation to choose among the shipments committed to them, retaining remunerative long distance transport to be made by road to the prejudice of the Railway. The yearly tonnage of transport committed to the Railways by the Collection Companies since 1943 is given below :—

1943	713 515 tons.
1944	675 335 »
1945	603 478 »
1946	659 226 »
1947	615 650 »

They consider that the Collection Companies should be allowed the existing freedom and facilities.

CHAPTER III.

Home collection and delivery services.

Home collection and delivery services are extensively in operation on the Pennsylvanian Railroad & Long Island Railroad and the British Railways and, to a lesser degree, on South African Railways. In India and Egypt they are confined to very few important towns.

The system of operation on the different Railways is summarized below:—

Pennsylvanian Railroad & Long Island Railroad.

About 2 900 motor vehicles of 1½ to 10 ton capacity (2 350 trucks and 550 truck trailer combinations) are operated over the entire system. They are usually operated within corporate limits of city or town, or 1 mile from freight station.

No lorry-stations are set up outside the Railway installations. Home deliveries take place from 8 a.m. to 5 p.m. Consignments are delivered the same day they are received or at the latest by the following day.

All shipments are given home deliveries unless they are not wanted. Outward consignments for dispatch are usually collected in the afternoon. Requests for collection and delivery are all received through the Railway.

The average distance covered by a lorry is 26 miles a day and the efficiency is about 6 tons per 8-hour day.

Generally, only one driver is provided with each lorry. No extra charge is provided for home collection and delivery services.

The cost of operating the service is 3.22 dollars per net ton (1947).

Taken as a whole, 75.1 % of the L.C.L. traffic handled by the Railway is dealt with by home collection and delivery services. The quantity handled varies from region to region according to population and degree to which it is industrialized.

The services are worked by a contractor chosen by agreement. The termination of contract is subject to 30 days' notice on either side. The contractors provide sufficient lorries to work the services. Motor lorries (petrol) are considered more efficient.

The route is determined by the lorry owner, while the number of lorries to be put in daily service varies according to the volume of freight to be handled.

Loads are checked into lorries in presence of lorry men who make the necessary tally. Railway employees do not accompany the lorries. Consignments are in the sole custody of the contractor's men.

Efficiency of the lorries is controlled by the owner.

There is no limit to the same contractor getting several cartage contracts.

Payment is made on a per ton basis, as it is the simplest and the easiest measure.

Contractors are responsible for loss, damage or delay occurring while the goods are in their custody.

The Railway and the contractor

exchange receipts for goods. Condition of goods is noted on the receipts.

British Railways.

Cartage services are operated by the Railways themselves. As a first step, the town or area served by a station is divided into a series of « rounds », each being arranged according to the potential traffic within its boundaries, due regard being paid to distance from the station. The depot is allocated sufficient horses and/or motors to meet average requirements, peaks being catered for by station relief in the case of very large depots operating substantial fleets; in other cases such relief is provided by District control. Where this is incapable of meeting requirements, an additional allocation is made from reserves at the disposal of Headquarters control. Thus they have, in broad principle, three divisions of the total fleet : (1) establishment or permanent; (2) mobile relief within a district and (3) mobile relief controlled by Regional Headquarters.

Another source is to be found in the casual hire of supplementary vehicles with drivers from local road carriers. In the case of stations employing agreement cartage contractors, the organization of collection and delivery is left to the contractors concerned, the responsibility being placed upon them to perform the whole of the work available. This is still under remote control by appropriate railway officers.

The capacity of petrol driven lorries ranges from 1 ton to 12 tons. Included in the lower ranges are articulated tractor units (or mechanical horses) of 30 cwts, and 3 tons capacity operating with semi-trailers in the ratio of about 2 ½ trailers per tractive unit. This type of unit is used principally in substitution of displaced horses in the collection and delivery of goods within a limited radius of station premises.

Lighter capacity 4 wheel motors are used for longer distance « Carriage & Delivery » of « smalls » traffic, whilst in the higher capacity ranges articulated 6 ton vehicles (mechanical horses) deal with larger loads of miscellaneous traffic for areas contiguous to station premises and in addition with full loads transferred direct from or to railway wagons in station yards — not over platform.

The heavier 4 and 6 wheel lorries deal, in the main, with full load traffic over longer distances and are engaged in trunk haulage of miscellaneous traffic between Railway depots under Zonal schemes.

Electric vehicles are employed experimentally for the collection and delivery of small parcels. It is hoped to develop this type of cartage unit for collections and deliveries of goods and parcels within a limited range.

Types and number are set out below :—

Rigids (four or six wheel lorries with fixed bodies) :	
Capacities varying from 1 to 12 tons	6069
Articulated (mechanical horses : 3 wheel tractive units working with 2 wheel semi-trailers) :	
Capacities varying from 30 cwts. to 6 tons	5500
Articulated (4 wheel tractive units working with 2 wheel semi-trailers) :	
Capacities varying from 30 cwts. to 8 tons	301
Tractors (4 wheel) for hauling 4, 6 or 8 wheel trailers, etc.)	76
Semi-trailers (for operating with articulated tractors) :	
Capacities varying from 30 cwts. to 8 tons	12985
Trailers (4, 6 or 8 wheel) for operating with 4 wheel tractors :	
Capacities varying from 3 to 20 tons	970

Rigid vehicles, semi-trailers and trailers are substantially provided for the conveyance of ordinary traffic, but the whole embraces a proportion of vehicles specially constructed for abnormal traffic.

Horse cartage equipment comprises:—

Horses	8 500
Horse Drays	24 038

The latter are principally of the flat platform type for ordinary traffics.

« In boundary » is approximately 2 miles from the station. « Out boundary » up to 10 miles, but the latter is subject to an additional charge over and above the collected and delivered rail rate.

Limits of operation, as distinct from cartage distances covered by C. & D. rail rate, are changing with the development of zonal schemes.

Lorry organisations are based upon railway installations.

Traffic arrives at stations during the night and early morning, and deliveries commence at approximately 8 a.m. Practice depends entirely upon the opening time of premises in a particular area. At country stations serving farming communities, it is often possible to commence deliveries earlier. Special arrangements exist in regard to traffic for meat, fruit and vegetable markets, etc. These establishments usually work either throughout the night or from very early morning and railway vehicles are brought out to meet these circumstances.

Where the contract for transport specifies that delivery is not required, an advice is issued to the consignee and his instructions sought.

It has been the policy of the British Railways to encourage the public to leave cartage in the hands of the Railway organisations in order that traffic clearance may be co-ordinated in the general terminal organisation. The reverse of this envisages an uncontrolled medley of vehicles operated by numerous carriers and traders converging upon a station under chaotic conditions.

Collections often proceed concurrently with morning deliveries but generally speaking from approximately 2 p.m. cartage equipment is increasingly engaged upon collections for dispatch, peak being reached at approximately 4 to 5 p.m. when traders are completing dispatch of the day's output.

In the case of organised « rounds » as already outlined, the particular vehicle serving the round makes regular daily calls upon the works and premises within the area covered. Casual collections are made on request.

Motor vehicles average 22 miles per day, and horses 8 miles. Subject to distance qualifications, motors deal with approximately 2½ times their capacity in the course of a day, i.e., a 3-ton lorry will deal with approximately 7½ tons per day. Horses average 3 tons per day.

Only one man (driver) is provided with each vehicle or horse except in London and a few other large centres where an attendant is used for the purpose of assisting loading and unloading and bearing the responsibility of protecting traffic during absence of driver in populated areas. When vehicles draw trailers having 4 wheels or more, the presence of a second man is a legal obligation.

So far as miscellaneous traffic is concerned, the overall C. & D. rate includes charges varying from 4s. 2 d. to 6s. 10d. per ton at each end to cover in-boundary cartage in accordance with the nature of the merchandise. This scale is subject to increase in London and certain other densely populated areas. The charges are subject to the following minima :—

Not exceeding 1 cwt. . .	10½d.
Exceeding 1 cwt. but not exceeding 3 cwts. . . .	1s. 2½d.
Exceeding 3 cwts. . . .	1s. 8d.

For out-boundary cartage, a separate charge is raised based on 50 per cent. on the foregoing per mile or part thereof.

Generally speaking, horse cartage is

used for dealing with miscellaneous traffic collected from and delivered to premises within a radius of 1 or 2 miles of station premises. The policy of the British Railways is to gradually eliminate this class of cartage in favour of mechanically propelled vehicles.

Each railway station, from which collection and delivery vehicles radiate, is allocated sufficient transport to meet average requirements. Cartage organisation is controlled by station agent-in-charge or his deputy. At the commencement of work each day, he is able to measure whether the equipment at his disposal is sufficient to meet requirements. If it is not, the process already outlined in connection with Relief comes into action.

Broadly speaking, the responsibility for loading lorries is not attached to the driver or carman. Separate loading staff is employed, and, in the interest of economic cartage, efforts are made to have all vehicles loaded ready for the driver when he reports for duty. This practice is varied in particular cases and does not apply in the case of passenger train-conveyed small parcels, in which case the driver assists in the sorting and loading of parcels in the order of delivery.

In addition to the initial control exercised by the staff referred to above, statistical control is exercised, the operation of each vehicle being recorded daily and submitted in summary form to District Officer weekly and to Headquarters four-weekly. These statistics record :—

Tonnage or number of parcels carted;
Miles run;
Average motor miles per day;
Tons or number of parcels per day;
Wages cost;
Maintenance and running cost;
Overheads;
Total cost;
Cost per ton or per parcel;

and the basis of arriving at costs is determined by the Accounts.

Costs are not strictly comparable between one District and another. Due allowance is made for varying conditions.

In the cases where railway cartage is performed by other than railway owned equipment, cartage is performed either by —

(i) appointed cartage agents,

(ii) casually hired hauliers on a day-to-day basis.

There still remain a number of cartage contractors who have been employed under agreement over a number of years. Casual hauliers are employed without any agreement, and, generally speaking, selection is controlled firstly by efficiency and secondly by cost.

Cartage agents are normally subject to three months' notice, which operates reciprocally.

In the case of appointed agents payments are made on a « per ton » basis. As far as practicable, casual hire hauliers are treated in the same way, but, occasionally, there is no alternative but to hire on a « per hour » or « per day » basis. The « per ton » basis is considered the most satisfactory, as this ensures the traffic being moved expeditiously in the interests of profit expected by haulage contractor.

The request for all home collection and delivery is always addressed to the Railway. This procedure provides a check in preventing the contractor from diverting some shipments to his own profit.

Cartage agents are not debarred from getting several cartage contracts.

From the documents which provide a check, it is possible to determine whether losses take place during the rail transport or during the process of collection or delivery.

In Great Britain, there are several stations provided with cartage service

for the same towns but efforts are being made to co-ordinate cartage of several depots serving in individual towns to the maximum degree. Whenever there is sufficient passenger train traffic to any particular station for parcel, cartage vehicles are employed solely for parcels and others for the goods. At the smaller stations, however, it is the practice to deal with both goods and passenger traffic with the same equipment.

South African Railways.

On the South African Railways, collection and delivery services are operated at 124 of the larger stations. Ten of these services are operated by the Administration, whilst the remainder are worked by contractors who are appointed following invitation of public tenders. The cartage areas are, in all cases, determined in consultation with the Chambers of Commerce or the mercantile community and vary in distance from the central distribution and collection point which in all cases is the Railway depot concerned. Cartage services are operated according to the demand of the public. The mileage and frequency of the service are dependent on the extent of the traffic offering for collection and delivery. Tenderers are required to enter into an agreement for a period of 5 years on a standard draft. The Railway's official Tariff Book includes the compulsory cartage stations and the cartage fare which will be added to the rail tariff payable by the sender or consignee, whoever elects to pay the charge for rail conveyance. Settlement with the cartage contractor is effected on a « per ton » basis. There is no limit to the number of contracts for which any contractor may tender or undertake. The cartage agreement stipulates that a cartage contractor must not patronize competitive service which must be conveyed by rail and further requires him to promote business in the interest of the Railways. It is also a condition of the agreement that the cartage contractor will not bind the Railways in the matter of receipts for traffic collected and delivered and that the railway receipt will be handed to the contractor only after the goods have been received and checked by the Railway Department. Any discrepancies or litigation between the senders and the contractor on the condition of the goods, when handed to the contractor, are matters for adjustment between those parties and not the Railways. Cartage services serve the town only and embrace parcels, goods, express traffic, etc.

Egyptian Railways.

Motor lorries of 3 tons each are utilised for door-to-door service between 8 a.m. and 10 p.m. within 8 kilometres from the main station at Cairo and Alexandria. Distribution is effected within 2 hours after arrival of consignments at the destination station. Each lorry is accompanied by a motor driver, goods clerk and porter.

Charges for home collection and delivery services are levied in addition to the rail freight. The lorries are operated by the Railways and the work is controlled by special staff.

Indian Railways.

Collection and delivery service is confined to principal towns where the services are performed by contractors. Deliveries are effected in the morning and collections in the afternoon.

Charges are levied in addition to rail freight.

Contractor's supervision ensures efficiency and the contractor is responsible for the goods while in his custody.

General remarks.

Home collection and delivery services are being increasingly extended

to many towns. In areas of small density of population, the cost of terminal lorry conveyance is likely to be prohibitive, but taking into account the all-in service over the entire system, these stations do not materially affect the issue.

CHAPTER IV.

Concentration of miscellaneous traffic at centre-stations.

The system of concentrating miscellaneous traffic to centre-stations has not been adopted by many Railways to which references have been made. In view of the post-war difficulties in getting equipment and facilities, they have not been able to put into operation the scheme envisaged in this question. On the British, American and, to a certain extent, on the New Zealand Railways, the scheme has developed.

It is advantageous to carry out transport by rail only between small number of stations correctly choosing the points from where L. C. L. shipments could be distributed or to where they would be concentrated by road services. This would give expeditious service, improved wagon loading, economic and efficient use of rolling stock, minimize handling operations, reduce chances of damage to consignments, and serve effectively greater area. The selection of these concentration stations is made giving due consideration to the following factors :—

Geographical, junctions, contours, volume of traffic, position on main Railway system, terminal accommodation, both existing and potential.

The average cartage limit allotted to a centre-station for the purpose of road conveyance varies according to the conditions prevailing in the different areas. British Railways consider that direct collection and delivery service is effective up to approximately 16 miles and trunk haulage between 20 and 25 miles, while the Pennsylvanian Railroad & Long Island Railroad consider that the maximum should be 50 miles.

While considering the location of centre - stations, adequate allowance should be made for additional less than car-load traffic that would develop.

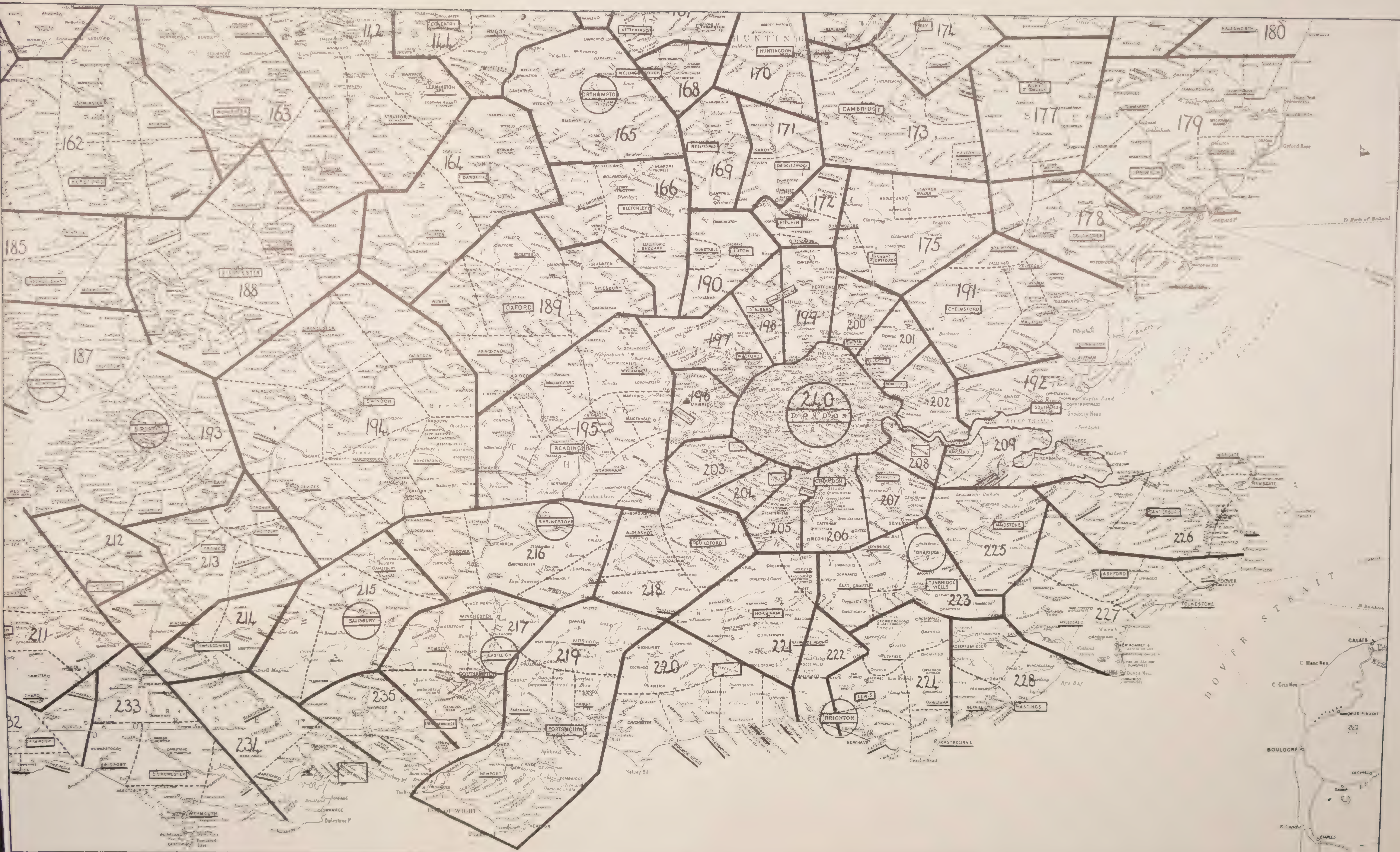
With the reduction in the number of forwarding and receiving stations consequent on the organisation of centre-stations, the number of through wagons capable of running without re-handling, definitely increases. It has been estimated that it will be possible to dispatch 80 % of the traffic on the British Railways and 50 % on the Pennsylvanian Railroad & Long Island Railroad and 70 % on the Egyptian Railways in direct wagons without re-handling.

In order to introduce the scheme, only a limited number of modern tranship sheds equipped with mechanical appliances should be provided to reduce manual handling and high labour cost.

Suitable train services will have to be provided. It would be preferable to have over-night service within a radius of 250 miles. The scheme is to minimize forwarding delays, provided collection schedules and train departures are closely related. Concentration will result in greater wagon load and improved turn-round. It will be possible to run more express freight trains resulting in better usage of stock. Transhipment is minimized thereby reducing handling cost and facilitating development of mechanization, and service to the public would be improved and would result in additional traffic to the Railways.

The main features which have to be considered in the selection of the adoption of existing Railway depots at centre-stations are :—

Adequate road and rail vehicles, berthing accommodation within the shed, sufficient yard accommodation



MAP OF THE SOUTH EASTERN REGION (BRITISH RAILWAYS) ILLUSTRATING THE SCHEME OF ZONAL ORGANISATION

Explanation :

Station underlined indicates Sub-Railhead.
Oblong block indicates Railhead.

Circle indicates Zonal Centre.
Oblong inside circle indicates Railhead - cum - Zonal Centre.

Thick black line indicates Boundary of each Railhead area.
Broken black line indicates Boundary of Sub-Railhead area.

for direct loading of outward traffic, adequate crane power, mechanical aids and facilities for internal movement of wagons.

Opinions differ regarding the method of engaging the cartage services at centre-stations according to the practice in vogue in different countries in regard to home collection and delivery services.

British Railways prefer to operate their own cartage services, while the American Railways prefer to do them on contract. It is desirable to base the payment for the cartage services on a « per ton » basis, as this places the responsibility upon the contractor in his own interest to perform the work as expeditiously as possible.

The same transport documents as are in vogue for collection and home delivery services are recommended.

Accounts for these are to be concentrated at rail heads or at centre-stations and should be done by Railways. Advices regarding home collection and delivery should be received by the Railways at their appropriate local stations. Scheduling of rounds should be done according to distance, nature and volume of traffic. In order to prevent diversion of traffic by contractors of less than car-load entirely in favour of the road, there should be adequate Railway supervision and orders for collection of traffic should all pass through Railway organisation and it is desirable that the terms of contracts should control the cartage contractors' activities.

The responsibilities for the contractor should be decided by mutual agreement or through an exchange of signed receipts and of transfer between Railway and contractor. As a matter of policy, it would be preferable to deliver local consignments from the freight shed, but occasionally an auxiliary or receiving office may be established.

A dealer or an agent may be appointed who would work under contract with the Railway and would carry the responsibility for initial and final documentation and for the proper custody of the goods while in his possession. It would no doubt be advantageous in selecting such sheds along the highways.

The rate applicable for conveyance under this scheme should be the scheduled rate to the normal sending or arrival station irrespective of how the transport is effected. If the rate is inclusive of home collection and delivery charges, as is in vogue on British Railways and Pennsylvanian Railroad & Long Island Railroad, no additional charge should be levied.

Under the arrangements contemplated, dispatch of express and postal parcels should be by special lorries and passenger trains and, in the case of perishable traffic, special arrangements will have to be made in accordance with the urgency of the situation.

The scheme introduced on British Railways is interesting and a brief description is given below :—

This system is regarded in Great Britain as Zonal Concentration and Collection and Delivery. For this purpose the country has been divided into approximately 280 areas. The size of these areas varies according to traffic density.

This « smalls » traffic may be loaded at one or two types of station only, which in broad terms are :—

(*a*) a selected station adjacent to the centre of the area, called a sub-railhead;

(*b*) the centre of the area, called a railhead.

Map has been prepared which illustrates the plan. A railhead covers the collection and delivery of traffic within a prescribed portion of the whole of the area. It may also deal with traffic to and from sub-railheads within its area, such traffic being forwarded to or received from

sub-railheads by rail or trunk road motor. A railhead receives traffic by wagon direct from sub-railheads, railheads, or zonal centres throughout the country. The railhead is linked to one or more zonal centres by rail and/or trunk motor according to the directional flow of traffic.

Zonal centres are places selected as giving the best service alternative to the railhead when direct wagons cannot be made up. In effect, zonal centres are the only places at which transhipment from wagon to wagon still occurs. The aim is ultimately to abolish transhipment entirely.

A typical example of the Zonal Collection and Delivery organisation is provided by the Swindon Railhead area (Ref. 194 on map) which covers approximately 1 000 square miles. The district is essentially agricultural but at certain points industry has become concentrated, thereby providing opportunities for good wagon loading.

Swindon, which is favourably placed from a train working point of view, is the railhead and connected to it are sub-railheads at Chippenham (20 miles from railhead), Cirencester (15 miles), Devizes (20 miles), Faringdon (12 miles), Hungerford (17 ½ miles) and Marlborough (13 miles).

Under Swindon and its six sub-railheads have been concentrated the « smalls » traffic of 44 smaller stations.

Prior to the introduction of zonal working, approximately 40 inwards wagons per day were dealt with at Swindon; this figure is now approximately 80, but wagon loading to smaller stations embraced in the scheme has been eliminated.

Swindon itself is principally a consuming town and its inwards traffic predominates over its forwarded; the number of outward wagons made is about half those received.

Trunk motors operate daily between Swindon and the six sub-railheads; a twice daily service being provided in each case with the exception of Hungerford, where the volume of traffic does not justify this course. Service to and from Bristol zonal centre is by rail.

This scheme affords considerable relief to Bristol station, the zonal centre and principal transhipping point for the area. Prior to the introduction of zonal working, a large number of stations included in the area received and forwarded practically the whole of their traffic via Bristol. Under the new working, that traffic, which is not dealt with in direct trucks at the sub-railheads, is, to a very large extent, being loaded direct to and from Swindon.

The Swindon shed is of fairly modern design with an extensive cart frontage which was not fully used. As a consequence, it was possible to base upon it a very large scheme with very little capital expenditure. The outwards traffic is loaded in the open by the direct loading system.

CHAPTER V.

Financial balance.

Each scheme is subjected to a close examination in the light of all relevant circumstances. Financial considerations are taken into account in the conduct of investigations. Improved service rather than financial considerations has been the decisive factor on the British Railways. On the other Railways, the cheapest and the fastest method of operation has been sought, involving the smallest number of handlings of goods at transhipment platforms.

On the Pennsylvanian Railroad & Long Island Railroad, the cost of operating wagons between 2 points, as

compared to the cost of operating lorries between the same points and the time saved by lorries were investigated. It was found that the use of lorries was more economical.

On the New Zealand Railways, it was found that, during the 12 months ending 31st March 1948, 71 566 wagons, equivalent to 178 822 wagon-days, were saved and made available for bulk traffic instead of being tied up in small consignments of general merchandise.

New tranship stations have been opened on Railways resulting in a reduction of personnel, cost of operation and expeditious movement of freight.

The cost of working the various elementary operations in regard to transport of less than car-load shipments, has not been calculated extensively on any of the Railways. Cost of conveyance by lorry of less than car-load traffic is 1 shilling and 7 pence per ton kilometre on the British Railways. The cost of loading and unloading operation often varies from place to place. On the Pennsylvanian Railroad & Long Island Railroad, it is 1.92 dollars per ton. The cost of home collection and delivery services is 9 shillings and 3 pence per ton on the British Railways while on the Pennsylvanian Railroad & Long Island Railroad it is 3.22 dollars per ton.

There is no doubt that the organisation of centre-stations is calculated to reduce claims for delay, loss and damage by reason of the greater degree of direct loading between points served by lorry services and to reduce the amount of handling during transit, though it has not been possible to work out the exact proportion of the gains achieved by improved operation under this scheme. The Pennsylvanian Railroad & Long Island Railroad have recorded a reduction of 50 per cent. in indemnities, while the Egyptian Railways estimate an anticipated reduction of 90 per cent. in indemnities.

CHAPTER VI.

Summary.

1. It is advantageous, both in regard to efficiency and economy, to carry L. C. L. consignments by rail only between a small number of stations correctly chosen, from where such shipments could be distributed or to where they would be concentrated by road service.

2. Centre-stations selected to deal with L. C. L. shipments should have adequate road and rail vehicles berthing accommodation within the shed, sufficient yard accommodation for direct loading of outward traffic, adequate crane power, mechanical aids and facilities for internal movements.

3. Cartage contracts for transport to centre-stations should be made on the same basis as adopted for home collection and delivery service.

4. Adequate provision should be made for increased traffic consequent on the improved service given to the public on the adoption of the scheme.

5. Train service will have to be modified to give proper co-ordinated service between road and rail.

6. Improved service rather than financial considerations should be the decisive factor in the adoption of the scheme.

7. Freight rates should be the same irrespective of whether consignments are transported by rail or road service to and from centre-stations.